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VOCATIONAL GUIDANCE AND THE TEACHER OF SCIENCE.

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The term "vocational guidance" is a very recent addition to our educational terminology; but the movement that it designates is not new. That one function of a general education is the discovery and direction of latent ability has long been recognized in theory. Comenius, in the *Great Didactic*, written about 1630 or 1631, explicitly states that boys

"... should learn the most important principles of the mechanic arts, both that they may not be too ignorant of what goes on in the world about them, and that any special inclination toward things of the kind may assert itself with greater ease later on." (*Great Didactic*, ch. xxix, Sec. 6.)

William Petty, writing in 1647, makes a proposal that, save for its quaint English, might have been penned the day before yesterday:

"We recommend . . . the compiling of a work whose title might justly be 'The Golden Book or the Great Description of the Money-Making Trades,' wherein all the practised ways of getting a subsistence and whereby men raise their fortunes may be at large declared. . . . Boys . . . might read and hear the history of the faculties [meaning here, the trades] expounded, so that before they be bound apprentices to any trade, they may foreknow the good and the bad of it, what will and strength they have to it, and not spend seven years in repenting and in swimming against the stream of their inclinations." (*The Advice of W. P. to Mr. Samuel Hartlib*, cited in Barnard's *American Journal of Education*, xxii, pp. 204-07.)

In the present movement which goes by the name of vocational guidance, the two problems that Comenius and Petty so clearly recognized are being aggressively attacked. Put briefly, these two problems are (1) the discovery of the specific abilities which the individual may possess, and which may fit him for certain occupations or unfit him for others; and (2) acquainting the individual with the various occupations that are represented in the division of labor, furnishing information as to the type of

¹A paper read at the Evanston meeting of the N. C. A. S. & M. T., Nov. 29, 1912.

work that they demand, the wages that they pay, the specific preparation that their service requires, the conditions under which advancement may be won and success achieved, their fascinations and their dangers. While closely related to one another, these are really two distinct problems, and in their solution, I believe, the high-school teacher, and especially the teacher of science, may plan an important part.

Before proceeding with this specific phase of my theme, however, it will be well to examine somewhat in detail the nature of these two problems, and the attitude of the present cult of vocational guidance toward their solution. This step is the more necessary because vocational guidance today may legitimately be called a "fad"; that is, while it is not in any sense a new movement, it is now being advocated perhaps for the first time by a group of special pleaders who are naturally enthusiastic concerning its possibilities and consequently tend to overestimate these possibilities,—and perhaps to underestimate the difficulties of the proposed program of reform, and to neglect the dangers that a too zealous advocacy of a "Cause" is likely to involve.

As to the large possibilities that the work of vocational guidance offers there can be no dispute. The pressing need of investigation and research in this field must be apparent to anyone who has the slightest acquaintance with the grave social and economic problems that have arisen through the rapid evolution of industrial life within the past few decades. Here if anywhere Spencer's definition of evolution accurately describes the process. Here, if anywhere, the homogeneous has given place to the heterogeneous; the undifferentiated has become the differentiated; the simple has been transformed into the appallingly complex. And the young person of today embarking without chart or compass upon the sea of occupation runs a hundred chances of shipwreck where the young person of the days of Comenius and Petty ran but one. There is, then, abundant justification for making vocational guidance a special field of study and investigation; there is abundant justification for stimulating and subsidizing research that shall reduce to some measure of law and order the forces that now operate without intelligent direction.

The need of such investigation and research is clearly revealed upon examination of some of the assumptions under which the advocates of vocational guidance have begun their work. The direct correlation between interest and ability is one of

these assumptions which needs, I believe, to be very carefully considered and very cautiously accepted even as a working hypothesis. That interest and ability often go together is the verdict of common experience. That interest may impel one to acquire ability is obvious enough. That increasing ability may awaken interest is no less true, but we do not often look at the problem from this angle.

The danger involved in this assumption of the direct correlation between interest and ability is suggested by the ease with which interest in superficial qualities may be confused with an interest in fundamental qualities. I may be pardoned for taking an illustration from my own experience. I have a very distinct recollection of a half dozen vocational ambitions that followed one after the other in my own childhood and youth. As I look back upon these dreams, it is very clear to me that each and every one of them was determined by superficial factors which caught my fancy. They were not all so thoroughly superficial as the first real ambition that possessed me, which was to play a bass drum in a brass band; but they differed from this only in degree and not in kind. Some of them remained with me for relatively long periods of time. At least two led to rather protracted efforts at special study and preparation before I found that the attractiveness that had appealed to me was only upon the surface and that, in every occupation that one may enter, there are many unattractive and uninteresting things to do. I do not wish to generalize unduly from this personal experience, and I have no doubt that there are many men who did not find their early interests so illusory. But I do believe that my own experience is sufficiently typical to warrant me in urging caution in assuming this direct correlation between interest and ability without, at least, very carefully defining our terms.

There is another factor that needs to be considered in this connection; namely, the influence of what may be called "fashion" as a determinant of interest. Adults tend to follow the prevailing "modes" in their interests. We create a lively interest in the prevailing mode of sport. Fifteen years ago, we were all bicycling. Today we use the bicycle as a useful means of getting to and from our work, but not commonly as a means of enjoyment. There was then a certain fascination and exhilaration about the sport that was, I am convinced, more than one-half due to the fact that "everybody was doing it." How many men who pore over the automobile journals, who talk with vivacity

about the features of next season's cars, are interested in automobiling for its own sake, and how many are interested because it is the fashion? Let me assert that the interest may be as spontaneous and effective in the latter case as in the former; but it will die when the fashion dies.

There is something here that is fundamental in life. And if it is apparent in adults, it is certainly to be found in children, and especially in adolescents. The rumor spreads about the college campus that a certain course is "awfully interesting" and the registrations leap up; the rumor may become a college tradition perpetuated from generation to generation. The course undoubtedly is interesting; the interest is real and spontaneous; it is not an artifact nor is it perfunctory. But my point is that a certain proportion of this adolescent enthusiasm owes its release to the factor of fashion.

And the same phenomenon is to be observed in the relative attractiveness of extended courses of study. The influence of fashion here is well illustrated by the statement made by the daughter of a University professor. Her father had asked her how she liked a certain young man who was acquiring the habit of coming to their house at frequent intervals. "The daughter replied that she liked him well enough,—“But,” she added, “he is only a student in the Arts College. Why doesn't he study something that is worth while like agriculture or engineering!” Agriculture and engineering happened to be in fashion at the university at that time—and I am glad that they are more fashionable now than they used to be. But again my point is that a good deal of the interest that our boys evince to-day in agriculture and in engineering is due to the prevailing “mode.” Many boys evince this interest who, under other conditions, would be just as effectively interested in other things.

And this suggests a second assumption of the advocates of vocational guidance that needs careful consideration. This is the assumption that natural abilities are highly specialized and that they may consequently be detected at a comparatively early age if we only refine sufficiently our methods of detection and identification. The ultimate goal of the vocational counselor is to be able to take the boy of fourteen, subject him to certain standard tests, study carefully the facts of his ancestry and of his early environment, and then map out for him the large lines of his career. This is an attractive program, and I should be the last to label it as a mere chimera. At the same time, the

assumption underlying it commits one to a species of fatalism that is somewhat repellent to a good democrat. Democracy, of course, may be a hopeless ideal,—an ideal which the laws of nature as expressed in the forces of heredity will permanently keep society from realizing. It is clear, however, that it is unnecessary to accept this assumption in advance of the evidence which may or may not support it,—and it is clear that the burden of producing evidence must certainly rest with the fatalistic doctrine rather than with the doctrine that keeps open the door of possibility.

No one would deny that nature sets limits to individual achievements; no one would deny that, if one's limitations are likely to lead one into a cul-de-sac of assured failure, these limitations should be clearly and forcibly pointed out. But the instances in which this can be done with certainty and without injustice are at the present time extremely rare. Certainly a boy who is color-blind to reds and greens should not be permitted to realize an ambition to run a locomotive. Color-blindness is an abnormality that can be readily detected, and one that cannot be corrected. A few other sensory defects are in the same class in their relation to the problem of vocational guidance. And it is possible that the experimental psychologist may devise and perfect tests for other types of ability that will indicate with equal accuracy weaknesses which would justify society in ruling individuals out of certain occupations. Professor Münsterberg, I believe, has suggested that he can determine by tests whether a boy ought to go into an occupation requiring concentrated attention or one in which attention must be dispersed,—as in watching a number of shuttles to detect any which happen to be out of order. Another psychologist states that it is practicable to measure the ability of the individual to acquire a high degree of manual skill. These statements involve possibilities that may be realized; but it would be dangerous to employ such tests at the present time with the belief that they are fully trustworthy.

Much more sensible is the policy that has been adopted in one of our large city school systems. When a boy who has reached the end of the compulsory-education age applies for a "work certificate" he is taken to a laboratory and subjected to a number of tests. He is examined for color-blindness, for acuteness of hearing, for ability to concentrate attention, for ability to deal with abstractions, and the like. He is also subjected to a careful physical examination. Upon the basis of these tests, he

is advised cautiously with regard to certain occupations that he ought not to enter. But this treatment is only tentative. The records of the tests are filed; the boy's address and the occupation that he has chosen are recorded; and he is brought back at intervals of six months to be retested. The aim is to determine the influence of different occupations upon different types of ability, and this, it is clear, may be determined rather accurately through the massing of data that is possible under this system. In the course of time the student of guidance may draw from these data certain inferences that will form a firm foundation for a real science of vocational direction.

There are two points of view, either of which it is perfectly legitimate to adopt in the present state of our knowledge concerning human nature. One view is that abilities are highly specialized through native endowment; the other is that natural ability is somewhat general,—that native endowment supplies the individual with a nervous system which, while it differs from other nervous systems in important particulars, can in the majority of instances be trained to do any one of a large number of operations with approximately equal ability. It has seemed to me that, pending further evidence, the latter hypothesis is the safer guide for educational practice. But this does not mean that the problem should not be thoroughly investigated from a quite impartial point of view; nor does it mean that we do not recognize rare cases of decided natural talent. It simply means that we have a tremendous faith in the resiliency of human nature and in the potency of training; this faith seems justified with reference to the great majority of individuals; it ought not to be upset unless the evidence against it thoroughly warrants a change of front.

The conditions of success or failure in human occupations are extremely difficult to unravel. The lives of many of our greatest men reveal crises where, it would seem, the merest accident has turned the scale and given immortality to a name that might otherwise have been forgotten. A little different falling of the ballots in the Chicago convention of 1860 would have kept Lincoln from the White House. If Lee's fidelity to his state had not been so strong as to override his loyalty to the Union, Grant might never have had the opportunity to rise from obscurity and apparently total failure to honor and prominence.

The influence of the accidental factors must always form an irritating x in the problem of individual achievement.

The first problem of vocational guidance, then—the problem of direction or the discovery of talent—is one that offers innumerable difficulties, and involves grave dangers.

The second problem,—that of vocational enlightenment,—is much simpler, and toward its solution the high-school teacher may contribute a great deal. The work here is purely objective. It does not involve an analysis of temperament, or a fine balancing of heredity against environment, or an exercise of the gifts of prophecy. It means laying before the boy or the girl the facts that have to do with human occupations. It means an analysis and a description of purely objective phenomena,—a description that will portray vividly the conditions under which the work of different occupations is done. It means illustrating these descriptions by means of excursions, by talks by workers in these occupations, and wherever possible by a first-hand acquaintance with the processes involved.

A good many high schools are now systematically undertaking this type of vocational guidance. One school, for example, requires each pupil to take during the first year four different courses: (1) a course in general science which furnishes acquaintanceship with and information about the trades and professions for which scientific training is a prerequisite; (2) a course in commercial work, including commercial arithmetic, simple accounting, and commercial geography; (3) for the boys, a course in manual training which will open up the field of the mechanical and engineering trades and industries, and for the girls a course in household arts; and (4) for all pupils the usual work in English, which, while it aims to give that command of the Mother Tongue which is essential to everyone, whatever his occupation, is also illustrative of certain fields of vocational endeavor.

In other words, the first year's work in this high school is definitely planned with reference to the problem of vocational enlightenment. It aims to help the pupil to select a course for which he is suited and which he may follow consistently through the remaining three years of his high-school life. Whatever occupation he may choose to follow, he has at least had a preliminary view of a very large field,—and this should be a part of the *general* education of every boy and girl. Properly handled, work of this sort should give to every pupil an appreciation of

the work that others do, and upon this appreciation depends in no small degree that mutual sympathy and respect among the various classes of workers which will form the surest safeguard against social stratification.

Some of us would wish perhaps that the choice should not fall so early in the pupil's life; but in this respect educators cannot be choosers. If the high school is to serve its community in the most helpful way it must do the best that it can for pupils who *must* make an early choice of vocation.

An appreciably large number of pupils will not, of course, make the choice at this time; and for these the general courses of the high school may well be centers of a more comprehensive and a more detailed vocational enlightenment; and in this connection the science courses are particularly important. Ever since the introduction of the sciences into the secondary curriculum their precise function in that curriculum has been a matter of dispute. The original sanction which led to their introduction was doubtless economic in its nature, but the early conception of the economic service which science could offer was exaggerated. As the high schools came to lose their original character as finishing schools preparing for life, and to take on the character of fitting schools preparing for college, the science work came more and more to be dominated by the preparatory and disciplinary ideals, and the original economic function became still further obscured.

Today the movement in secondary education is back toward an adequate recognition of the finishing function represented by the early high schools, and the science courses are among the first to feel the impetus of this movement. And yet the naïve conception of the value of science that led to its introduction is hardly sufficient today. We must have a broader connotation for the word, "practical," than that which once prevailed. Many of the results which the advocates of the so-called practical education have in mind can be secured only through highly specialized courses which, unless the student goes into the very specific type of work toward which the course aims, may turn out to be intensely impractical in the end.

And so the task of making any phase of "general" education truly "practical" is to determine what elements it represents that can be made really valuable to anyone irrespective of his particular vocation. And right here in the science work we have, I think, in the suggestion of vocational enlightenment, a possibility

of usefulness that the skillful teacher may richly realize. When so important a part of the occupational life of society depends upon the application of scientific principles, does it not become an important function of science courses to interpret this occupational life to the pupil? And is it not one of the functions of the science teacher to breathe again into the facts and principles which he passes on to his pupils the vitality which can come only from associating them closely and intimately with those human needs and human problems in which they had their origin and through their service to which alone they are justified?

I am aware that I have just asked questions which a good many science teachers have already answered most effectively, not only in the discussions of their problems but in the results of their work. My only apology for making a suggestion to men who are thoroughly competent to work out their own problems is that this new movement of vocational guidance through its emphasis of the value of and necessity for vocational enlightenment, relates itself in a most stimulating way to the task of still further enhancing the service which our science courses are now rendering.

TRAVELING DRAWING EXHIBIT FOR CITY SCHOOLS.

It will soon be possible for any city school to have a drawing exhibit of national significance practically without cost. Dr. Henry Turner Bailey and Mr. Royal B. Farnum are preparing for the United States Bureau of Education an exhibit of the best examples of drawing and art work in the elementary, high, and normal schools of the United States, as well as one or two of the art schools. The exhibit is to be sent to any city desiring it upon payment of the cost of transportation from the city last using it. The transportation charges will be small.

The exhibit is not to be a large one, but it is being selected with unusual care, so as to show the work that will be most suggestive to teachers, children, and school officers. It will be ready for shipment about January first, but cities desiring it should make application at once to the Commissioner of Education, Washington, D. C., in order that it may be dispatched to as many localities as possible with the least expense to each of them.

Dr. Claxton believes that this small but choice exhibit of drawing work, compiled by two acknowledged leaders of art teaching in America, will do much to aid the cause of drawing and art in the public schools.

AN ELEMENTARY EXPOSITION OF THE TIDES.

BY EDISON PETTIT.

High School, Minden, Nebr.

(Continued from the January Number.)

TIDES ON LAKES AND SEAS.

Equation (13) determines the height of a tide on a planet. Now suppose two planets x and y were at the same distance R from the attracting body of mass M . The ratio of the tides on the respective planets then is

$$(17) \quad \frac{T_x}{T_y} = \frac{\frac{M D_x}{R^3}}{\frac{M D_y}{R^3}} = \frac{D_x}{D_y}.$$

Hence the tides on the two planets have the same ratio as their respective diameters. Now a lake or land locked sea may be considered as water on a small planet, therefore, since they are at practically the same distance from the moon or sun as the earth, tides will be raised on them whose heights are to those on the ocean as the diameter of the lake or sea is to the earth's diameter. An examination of Figure 4 will show that the longest diameter of the lake must be used, also the height of the ocean tides in the same latitude as the lake. Then letting T_y be the height of the tide on the ocean in the latitude of the lake whose longest diameter is D_x miles, the height of the tides T_x on the lake will be by (17)

$$(18) \quad T_x = \frac{T_y D_x}{7920}.$$

Lake Michigan for instance is 350 miles long and ocean tides in its latitude are about 40 centimeters high. By (18) then the height of tides on Lake Michigan should be

$$T_x = \frac{40 \times 350}{7920} \text{ cm} = 1.7 \text{ cm}.$$

Such tides it will be seen are very small and difficult to detect. Careful measurements made at Chicago show a tide of about 4 cm., the increase in height being due to shallow water near the shore as we shall see later.

Not only does the moon have a tidal effect on the earth, but in turn the earth has a tidal effect on the moon. Suppose the moon were surrounded by oceans much like the earth; then we may find the height of the tides the earth would produce on

the moon by comparing them with the tides the moon raises on the earth as expressed in equation (13). Let T = the height of the tides on the moon, t = the height of the lunar tides on the earth, M the mass of the earth, m the mass of the moon, D the diameter of the earth, d the diameter of the moon, and R the distance to the moon. Then by equation (13)

$$(19) \quad \frac{T}{t} = \frac{\frac{c M d}{R^3}}{\frac{c m D}{R^3}} = \frac{M d}{m D}.$$

Now $M = 81.5m$; $D = 7920$ mi; $d = 2163$ mi. and $t = 50$ cm. Replacing these values

$$\frac{T}{50\text{cm}} = \frac{(81.5m)(2163)}{m(7920)}, \quad T = 1112\text{cm} = 36.5 \text{ ft.}$$

This is as high as the highest hurricane waves on the earth, and retarded by shallow water on reaching the shore they would be augmented to several hundred feet. If then the ancient moon was ever covered with oceans of any great extent these enormous tides must have largely contributed to the wrecking of our satellite.

THE AMOUNT OF THE TIDE RAISING FORCE.

Not only does the tide raising force of the moon and sun disturb the ocean waters, but also tends to separate loose bodies from the earth's surface. This will then cause these bodies to lose a part of their weight.

By equation (1) we can express the moon's attraction in terms of gravity and thus reduce the tide raising force determined by equations (10) to a fraction of the earth's attraction on a body, i. e., its weight.

Let g be the intensity of gravity at the earth's surface, i_0, i_1, i_2 the intensities of the gravitation of the moon at the points B', A' and D' , figure 4, M the mass of the earth, m the mass of the moon, r the radius of the earth, and R the distance of the moon. Now $M = 81.5 m$ and $R = 60 r$, therefore, by equation (1),

$$(20) \quad \left\{ \begin{array}{l} i_0 = \frac{c m}{60^2 r^2} \\ i_1 = \frac{c m}{59^2 r^2} \\ i_2 = \frac{c m}{61^2 r^2} \\ g = \frac{81.5 m}{r^2} \end{array} \right.$$

then

$$(21) \quad \begin{cases} \frac{i_0}{g} = \frac{1}{81.5 \times 60^2}, & i_0 = \frac{g}{81.5 \times 60^2} \\ \frac{i_1}{g} = \frac{1}{81.5 \times 59^2}, & i_1 = \frac{g}{81.5 \times 59^2} \\ \frac{i_2}{g} = \frac{1}{81.5 \times 61^2}, & i_2 = \frac{g}{81.5 \times 61^2}, \end{cases}$$

hence the tide raising force in terms of the weight g of a body is

$$(22) \quad i_1 - i_0 = \frac{g}{8582400}, \quad i_0 - i_2 = \frac{g}{9022600}.$$

This means that when the moon is on the meridian the weight of a body is decreased by one $8\frac{1}{2}$ millionth and when the moon is in the antimeridian the weight of a body is decreased by one 9 millionth. In the former instance a ball of cast iron $32\frac{3}{4}$ feet in diameter would loose one pound of its weight. When the moon is on the horizon its attraction combines with that of the earth, forming a resultant force which is greater than that of the earth by one 17 millionth. When the moon makes an angle of 35° with the horizon, this resultant is exactly equal to gravity. Many attempts have been made in the past few years to detect this force but all have failed on account of its minuteness. Pendulum clocks are slightly affected by this tidal force.

EFFECTS OF THE TIDES.

I. *Establishment of the Port.* According to our previous discussion, one would suppose that for a given place the tide would come in when the moon came to the meridian circle. Experience however shows that this is not the case, for the moon always comes to the meridian circle at a fixed time before the high tide. This time interval is called the "establishment of the port" and varies for different places.

Now the earth E , Figure 5, rotates in the direction of the arrow toward the east, and the moon revolves in the same direction about the point C in such a way that the earth makes $27\frac{1}{4}$ revolutions while the moon makes one. Since the moon moves so slowly let us suppose that it stands still at M . In this instance if there were no friction between the earth and the ocean a tide would be raised at A° and S , but this friction between the earth and the water will drag the tide wave along in the direction of the earth's motion until it is arrested by the moon's attraction, whence it will be held at an angle $B'''EM$ to the east of the moon

which will be increased by an increased roughness of the ocean bottom and numerous islands. Suppose a lighthouse AB in the ocean at low tide. If it were not for the friction of the ocean bed the earth in its eastward rotation would move the tower into the high tide at $A^{\circ}B^{\circ}$, but because of this friction the tide has been displaced and the lighthouse will not reach it till it arrives at $A'''B'''$. The time required to pass from $A^{\circ}B^{\circ}$ to $A'''B'''$ is called the establishment of the port for the lighthouse. Notice that in the truest sense it is the lighthouse that moves into the tide and not the tide into the lighthouse. A person in the lighthouse sees the tide coming in from the east, hence

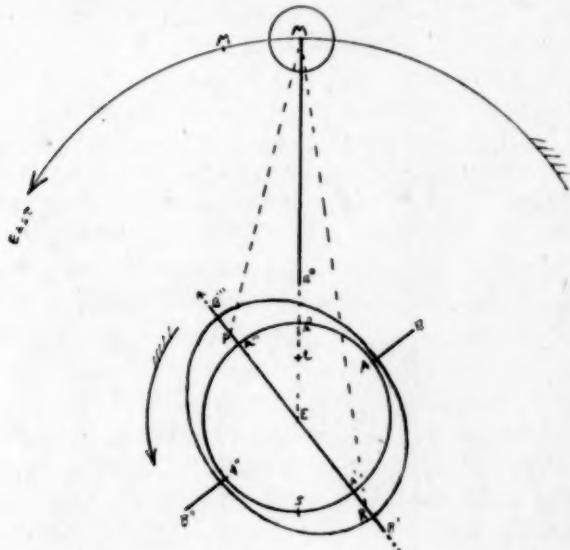


FIG. 5.

a tide wave moves westward over the ocean surface. Let there be a series of islands at about the position A° to the east of the lighthouse AB . It is evident that these islands will reach the tide before the lighthouse and because of the increased friction swing this tide wave with them farther to the east, increasing the angle $A'''EA^{\circ}$. This evidently increases the establishment of the lighthouse since it will require a longer time for it to move from $A^{\circ}B^{\circ}$ to $A'''B'''$. Let the earth now continue to rotate about E back to the position $B'''A'''$. It will be seen how the lighthouse will experience all the tide variations. But while the earth is thus rotating the moon is also moving in the same direc-

tion covering $\frac{1}{27}$ of its orbit and nearly reaches M' when the lighthouse is back at A''', therefore, the high tide will no longer be at A''' but will have moved to the east through an angle equal to that moved through by the moon, having been thus moved by the earth's friction. It will require, therefore, that the earth turn $\frac{1}{27}$ rotation more to reach the high tide again. This will of course amount to $\frac{1}{27}$ days or about 51 minutes. On the average then 24 hrs. 51 min. intervenes between each same high or low tide and between every change of tide 6 hrs. 13 min. At the time of the spring tide this interval is 24 hrs. 38 min. when the tide is said to prime and at the time of neap tide it is 25 hrs. 6 min. when the tide is said to lag.

II. *Spring and Neap Tides.* We have seen how the sun forms a tide $\frac{5}{11}$ as high as that of the moon. When the sun and moon are in a straight line the solar tide is added to the lunar which is the spring tide, but when they are 90° apart the sun takes some of the water away from the lunar tide, which is then called neap tide. The relation of neap to spring tide then is

$$(23) \quad \frac{N}{S} = \frac{1 - \frac{5}{11}}{1 + \frac{5}{11}} = \frac{6}{16} = \frac{3}{8}, \quad N = \frac{3}{8}S.$$

Neap tide there is only $\frac{3}{8}$ as high as spring tide. Bear in mind however that both are high tides.

III. *Prime and Lag.* At spring tide the water being deeper than at neap tide it offers less friction to the ocean bed, since then many islands, reefs and other barriers will be flooded. Experiment will show that an increase of depth lessens the friction of running water. At spring tide then the angle A'''E A° will be decreased since the decreased friction will enable the moon to draw the tidal line A'A''' more nearly to E M, and this process will continue for some time, making each recurring tide come in a little sooner than usual. The reverse will be true of neap tide.

IV. *The Tidal Bore.* As the tide wave approaches the shore the depth of the water diminishes and the friction of the bottom increases; the wave is retarded and the crests crowded more closely together, which increases the height of the wave as it rushes up on the shore. If two islands or head lands are so related as to form a V opening toward the tide, the water will rise to great heights in the narrow portion. Fix two glass plates together so that they form a dihedral angle nearly, yet so that the nearest the plates approach each other is about a half an inch. If these plates be half immersed in water and rapidly moved

along with the widest opening ahead, the water will be seen to pile up between the plates much as it does in the case of the two islands. When the tide is struck by a river mouth this effect combined with the opposing current causes the tidal bore.

V. *Effect of the Tides on the Earth and Moon.* The continued friction of the tides, it is easily seen, will tend to lengthen the day since it is eternally opposed to the earth's rotation. However, observations seem to indicate that this cannot amount to more than $\frac{1}{1000}$ of a second in the past 2,000 years. There are many conditions such as the earth's contraction which tend to shorten the day, so that it is difficult to determine in just what measure the tides are retarding the earth.

The tide P, Figure 5, is nearer the moon than the tide R, hence the earth tending to pull this tide by its friction to the east will also tend to drag the moon along after it. This will increase the velocity of the moon, making it move in a line more nearly straight, from which it follows that the moon's orbit will be increased in size, the moon thrown farther from the earth and the length of the month increased.

It is upon this basis that Prof. George Darwin founded his tidal theory. He concluded from a series of calculations that there was a time 54,000,000 years ago when the earth and moon turned about a common center in 3 hours. At this time an intense solar tidal action separated the liquid masses, the earth then raised a huge tide on the moon and, cooling, it has ever kept the same face toward the earth, like a great plumb-bob. Tidal forces as we have seen then began lengthening the day and month and drove the moon from the earth to its present position. At the end of 150,000,000 years from now the day will be 70 times as long as at present and exactly equal to the month, so that both planets will keep the same face toward each other. On this hypothesis the moon would then be 451,408 miles away and a permanent tide would be raised on the earth.

Years ago the astronomer Hansen proposed a theory based on calculations that this tidal effect of the earth on the moon while yet in the molten state had drawn all the lighter materials of the moon into the bulge on the side next to the earth. It followed that this bulge might be considered as a high mountain extending toward the earth. Then, although the top of this "mountain" which we see is barren and without atmosphere or water, still on the other side of the moon might be water, air and all conditions necessary to sustain life.

VI. *Tides in the Atmosphere and Soil.* Since there is a considerable tide formed in the liquid portion of the earth, a still greater tide should be formed in the atmosphere. This added mass of air would increase the barometric pressure a few tenths of a millimeter were it not for the fact that this same tidal force diminishes gravity. This is the only known way in which the moon could in any way affect the weather, and how insignificant it is will be understood when we recall that the barometric variation amounts to about 40 millimeters in our latitude. When the barometer falls the tide rises and vice versa, the variation of the tide being about one foot for every change of one inch of mercury pressure.

A NATURAL OBJECT-LESSON IN HEREDITY.

The long-looked-for history of the Kallikak family has at last come from the press of the publishers. Under the auspices of the Training-School for Feeble-Minded at Vineland, N. J., Dr. Henry H. Goddard has investigated and compiled the results of his work in the heredity of this most remarkable family. During Revolutionary days, the first Martin Kallikak (the name is fictitious) descended from a long line of good English ancestry, took advantage of a feeble-minded girl. The result of their indulgence was a feeble-minded son. This son married a normal woman. They in turn produced five feeble-minded and two normal children. Practically all of the descendants of these defectives have been traced as well as those of the two normals.

From both normal and defective descendants of this union came a long line of defective stock. There were 480 in all. Of these thirty-six were illegitimate, thirty-three sexually immoral, twenty-four confirmed alcoholics and three epileptics. Eighty-two died in infancy, three were criminal, eight kept houses of ill fame and 143 were distinctly feeble-minded. Only forty-six were found who were apparently normal. The rest are unknown or doubtful. But the scion of the good family who started this long line of delinquent and defective progeny is also responsible for a strain of an entirely different character. After the Revolutionary War was over, he married a Quaker girl of good ancestry and settled down to live a respectable life after the traditions of his forefathers. From this legal union with a normal woman there have been 496 descendants. All of these except two have been of normal mentality. The exceptions were cases of insanity, presumably inherited through marriage with an outside strain in which there was a constitutional psychopathic tendency. In all the 496 there is not an instance of feeble-mindedness. The offspring descended from this side of the house have universally occupied positions in the upper walks of life. They have never been criminals or ne'er-do-wells. On the other hand, there has not been a single instance of exceptional ability among the descendants of the first Martin Kallikak and the feeble-minded girl. Most of these descendants have failed to rise above the dead level of mediocrity; indeed, most of them have fallen far below even this minimum standard. This striking study in heredity is commented on at length in a recent number of *The Journal of the American Medical Association*.

**MATHEMATICAL INSTRUCTION AND THE PROFESSORS
OF MATHEMATICS IN THE FRENCH LYCÉES FOR
BOYS.**

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(Continued from the January Number).

In France, as everywhere else, the success of the system depends much on the personality of the professor. A renowned Paris lycée instructor who had a genius for getting hold of his boys has recently died. No less than 35 of his pupils were admitted to the École Polytechnique in a single year. The ordinary professor has to be content with a half or a third of this number. But the success of a class is, by happy arrangement, not left to depend wholly upon a single man. Take, for example, lycée Saint Louis, which is the greatest preparatory school for the École Normale Supérieure and the École Polytechnique. There are four Classes de Mathématiques Spéciales and for all the members of these classes, conferences, interrogations and individual examination are organized. These exercises, which complete the daily instruction, are conducted by one of the professors in the lycée itself, or by one of those from the Collège de France, the Sorbonne, the École Polytechnique, the École Normale, from other lycées or from the collèges. Incapable students are thus speedily weeded out. Of perhaps greater value than the solidity of the training got in this way is the fact that the interest of the pupil is sustained.

With the end of the year the élève has his first experience of a *concours*. Previously he has found that it was necessary only to make a certain percentage in order to mount to the next stage in his scholastic career; but now it is quite different. In 1908, 1,078 pupils tried for admission into the École Polytechnique, but only 200, or 19.5 per cent, were received; for the department of science in the École Normale Supérieure, 22 out of 274, or 8 per cent, succeeded. In each case the number was fixed in advance by the Government according to the capacity of the school; the fortunate ones were those who stood highest in the examinations, written and oral. In the case of the École Polytechnique, the written examinations were held in all the lycées which had a Classe de Mathématiques Spéciales. The 387 candidates declared *admissible* were then examined orally at Paris, and from

them the 200 were chosen. Similarly for the École Normale, the written examinations are conducted at the seats of the various academies and the oral at Paris. Since 1904 the concours passed by the École Normalians has been that for the *bourses de licence*, open to candidates of at least 18 years of age and not more than 24. Certain dispensations in the matter of age are sometimes granted. The value of the bourse, for the section of science, is from 600-1,200 francs a year and is intended to help the student to prepare for the licence and other examinations required of prospective professors in the lycées and universities. The candidates leading the list in the concours are sent to the École Normale Supérieure for from three to four years. It is necessary for the six or seven other *boursiers* to prepare for future examinations at the various universities of the provinces. Their bourses last regularly for two, and exceptionally for three, years.

But to return to our élèves of the Classes de Mathématiques Spéciales. At the end of the first year, when 18 or 19 years old, they usually present themselves for the concours of both the bourse de licence and the École Polytechnique, the examinations in the former being more strenuous and searching. Only from 2 to 5 per cent, succeed on the first trial. The others then go back to the lycée and take another year in the Classe de Mathématiques Spéciales. Many points not fully understood before are now clear, and at the end of the second year from 25 to 28 per cent are successful. The persevering again return to their *Classe* and try yet a third time (the last permitted for the bourse de licence); but it is a matter of record that less than one-half of those who enter the Classe de Mathématiques Spéciales succeed even with this trial. This is usually the last trial possible for entry into the École Polytechnique, as the young man who has passed the age of 21 on the first of January preceding the concours may not present himself. The remainder of the students either seek for entrance into government schools with less severe admission requirements, and thus give up their aspirations to become mathematicians, or else continue their studies at the Sorbonne. The candidate who heads the list in each of these concours has his name widely published. In the case of the bourse de licence he is called the *cacique*, and he very frequently tops also the École Polytechnique list.

If the work in the Classe de Mathématiques Spéciales is so enormously difficult that only 2 to 5 per cent of its members can,

at the end of one year, meet the standard of requirements of the examinations for which it prepares, why is not the instruction spread over two? Since nearly all the mathematical savants who now shed lustre on France's fair fame have passed from this remarkable class on the first trial, there can be no doubt that the answer to this question may be found in the fact that the government ever seeks her servants among the *élite* of the nation's intellectuals.

Those who pass from the *Classe de Mathématiques Spéciales* at the early age of 18 years are not numerous, but Borel and Picard are such men while Goursat entered the *École Normale Supérieure* at 17 years of age. For the average boy the lycée course is heavy and more than once he may have to halt in order to repeat a year. The system of training is largely formulated to develop to the full the powers of the brilliant boy and to promote his rapid advancement. For such youths poverty is no detriment. Every lycée has a number of bursaries (covering all expenses) which it distributes to just such boys coming with distinguished records from the primary schools. If the boy's record is sustained, renewal of his bursary from year to year is inevitable.

We have now seen something of the nature of the remarkable mathematical training which the French boy may receive in the lycée and have incidentally remarked that the men who have given this training are also exceptional. In conclusion I propose to describe very briefly the preparation necessary to become a lycée professor and the inducements offered by the state to the youth of the country to enter upon this preparation.

We have had occasion to point out the strong influence which the *École Normale Supérieure* and *École Polytechnique* exert on the careers of the flower of the French youth; how that instead of entering the university on passing the *baccalauréat*, as in America or in Germany, "they seek to enter these schools. The reason for this is not difficult to find. The *École Polytechnique* which prepares its pupils as military and naval engineers, artillery officers, civil engineers, in government employ, telegraphists and officials of the government tobacco manufactures, offers all of its graduates a career which is at once rapid, brilliant and certain. The *École Normale* practically assures its graduates at least a professorship in a lycée and prepares its élèves for this, or for a university career better and more rapidly than the university can do it."

Let us suppose that our future mathematical professor in the lycée is one of the eleven mathematical students who is successful in getting into the École Normale in a given year. He studies there for three years and receives special drill in pedagogy and in connection with courses of lectures which he hears at the Sorbonne and at the Collège de France. Almost the whole purpose of the drill and instruction is to prepare for two examinations, the *licence* and the *agrégation*.

The diploma *Licence ès Science*, which is necessary for all those who take up secondary teaching is granted to those who have 3 *certificats* in any one of three groups of subjects. Our mathematician is examined in the following subjects: (1)—Differential and Integral Calculus; (2)—Rational Mechanics; (3)—General Physics or some advanced topic in mathematics. The examinations may be taken singly in July or in November; each examination successfully passed entitles the student to a *certificat* for that subject. The examination consists of three parts, *épreuve écrite*, *épreuve pratique*, *épreuve orale*. The first two are written examinations of about four hours each. Theoretical considerations abound in the *écrite* while numerical calculation is characteristic of the *pratique*. The *orale* lasts for 15-20 minutes and is held before a jury of those professors who have the whole examination in charge. The pass mark is fifty per cent.

Unlike the *baccalauréat* and the *licence*, the *agrégation* is a competitive examination and is conducted by the state. The number who become *agrégés* each year is fixed in advance by the Minister of Public Instruction according to the needs of the lycées in the country. This number in recent years has been about 14; the number of candidates is usually about 80. Our candidate for this examination must have four *certificats*, (1)—Differential and Integral Calculus; (2)—Rational Mechanics; (3)—General Physics; and (4)—a subject chosen at pleasure in the advanced mathematical fields in which courses are offered. Just what is implied by the possession of one of these *certificats* we may not pause to consider further than to say that no one graduate course in any American university gives the pupil such a comprehensive grasp and mastery of the subject.

To pass the *agrégation* our future professor disposes of his three years as follows: During each of the first two years he passes the examinations for two of the four *certificats*. With these off his hands he turns his whole attention to preparing for the *agrégation* proper. This examination is unique in its

difficulty and exactions. As it is organized for selecting the most efficient young men in the country to take charge of the mathematical classes in the lycées, the examination turns largely on the subjects there taught. It consists of *épreuves préparatoires* and *épreuves définitives*. The former are four written examinations each of seven consecutive hours in length (7 a. m. to 2 p. m.)! The first two of these are on subjects chosen from the programme of the lycée in *mathématiques élémentaires* and *mathématiques spéciales*. The last two, based on the work of the candidates in the universities, are a *composition* on Analysis and its geometrical applications and a *composition* on Rational Mechanics. The *épreuves* are held at the seats of the various academies of France. Those who have reached a sufficiently high standard are declared *admissible*. Their number is usually a little less than twice the possible number to be finally received. They must present themselves at Paris for the *épreuves définitives*. These consist of two written examinations and two *leçons*. The written tests are an *épreuve de géométrie descriptive*, and a *calcul numérique*. Their duration is fixed by the jury, but it is usually four hours for each. The *leçons* which are supposed to be such as a professor might give (during $\frac{3}{4}$ -1 hour) in a lycée, are on subjects from the programmes of the classes: (a)—*Mathématiques Spéciales*; (b)—*Seconde Première C. D.* and *Mathématiques A. B.* The subjects are drawn by lot, and for each lesson the candidate has four hours to think over what he is going to say. No help from book or other source is permitted. The unfortunate who has little to say is speedily "adjourned."

The *agrégés* are those specially prepared by the State for the positions of *professeurs titulaires* in the lycées. Although this title is not conferred regularly till the *agrégé* has completed his twenty-fifth year, those who are younger receive temporary appointment for every *agrégé* may demand a position as his right. The salaries vary according to the *classe* of the professor. At Paris the lowest salary is 6,000 francs per year, and the highest, 9,500. In this range seven *classes* are represented; six, each differing from the one before by 500 francs, and the *hors classe*, for which the salary is 9,500 francs. Promotion from one class to another takes place by selection and by seniority. From the sixth (the lowest *classe*) to the third, the number of those who can be advanced each year by selection is equal to the number which can be advanced by seniority. In the second and first classes two advancements may be made by selection to one by

seniority. In choosing those for the *hors classe*, selection alone is taken into account. The promotions are made at the end of each calendar year, and take place so that there are always 20 per cent of them in the sixth classe, 18 in the fifth, 18 in the fourth, 16 in the third, 14 in the second, and 14 in the first. This arrangement is obviously a happy one, both by way of recognition of the merits of the unusually successful teacher, as well as those of him whose service is rather characterized by faithfulness.

In addition to the *professeurs titulaires* there are *professeurs chargé de cours*, who are usually selected from those Ecole Normaliens and those *admissible* to the agrégation, who fail to become agrégés. After 20 years of service they may become professeurs titulaires and receive the salaries we have indicated above. The government has, however, recently passed a law which gives the higher reward to the agrégé. It is to the effect that 500 francs per year shall be added to the regular salary of every agrégé. The real range of salaries mentioned above is then 6,500-10,000; in the provinces this reduces to 4,700-6,700. For the professeurs chargé de cours, the salaries at Paris vary from 4,500 to 6,000 francs; in the provinces, from 3,200 to 5,200.¹⁰ In the Premier Cycle the professors have 12 hours of teaching per week, in the second cycle and the Classe de Mathématiques Spéciales, 14-15 hours. Except for correcting exercises and filling out reports the professors have absolutely no obligations outside of class hours. They do not live in the lycées. The superintendence of the study of the élèves is carried on by *répétiteurs*, the more advanced of whom receive at Paris 2,600-4,600 francs for 36 hours service per week.

Attractions connected with a professorship in a lycée are, that the remuneration is ample to live on comfortably, that the work is not onerous but often not a little inspiring, that colleagues are brilliant specialists in the same or other lines of study, that the professorships are positions of honor and prominence in the community and that the incumbents are in demand in many ways which frequently materially increase their regular income. In general, only a professor in the first or *hors classe* has charge of the Classe de Mathématiques Spéciale with its members the pick of the French youth, but to their position all may aspire.

With inducements such as these it is no surprise to learn that, in marked contrast to America, France draws to the development

¹⁰The tendency of recent legislation is to exclude from the lycées all professors who are not agrégés.

of her system of secondary education much of the best mathematical talent in the country.

In the John Hay Library a few days ago, I came across an old Latin work which turned out to be the course of lectures on Greek Geometry, delivered at Oxford University in 1620,¹¹ by the erudite Sir Henry Savile. In the course of his concluding remarks he used the following language: "By the grace of God, gentlemen hearers, I have performed my promise; I have redeemed my pledge. I have explained, according to my ability, the definitions, postulates, axioms, and the first eight propositions of the *Elements* of Euclid. Here sinking under the weight of years, I lay down my art and my instruments."¹²

It is interesting to speculate on the thoughts which would likely pass through the minds of these "gentlemen hearers" were they privileged to listen for a time to the discussion of questions in geometry, and in other parts of mathematics, as carried on by master and pupil in a *Classe de Mathématiques Spéciales* of a French lycée.

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Of prime importance in the study of French Secondary Education for boys in the "*plan d'études et programmes d'enseignement dans les lycées et collèges de garçons* [Arrêtés du 31 mai 1902, des 27, 28 juillet et 8 Septembre, 1905, 6 janvier, 26, 30 juillet et 5 août 1909]." Paris (Librairie Delalain), pp. 264—Next in importance should be mentioned Tomes II and III (Librairie Hachette) of the report of the French sub-committee of the International Commission on Mathematical Teaching. Tome II (159 pages), devoted to secondary education and edited by M. Bioche contains special articles by MM. Bioche, Blutel, Lévy, Guittou, Th. Rousseau, Beghin, Muxart, Lombard. In Tome III (123 pages), Superior Education is discussed and articles by various writers are edited by M. Albert de Saint-Germain. A perusal of this volume will give a good idea of the course of training for lycée teachers. Each year about 100 pages of M. H. Vuibert's *Annuaire de la Jeunesse*, Paris (Librairie Vuibert), is devoted to "Enseignement secondaire des garçons." Information as to the cost of the various classes in the different lycées of France, bursaries offered, regulations with regard to uniform

¹¹*Praelectiones tresdecim in principium elementorum Euclidis, Oxonii habitae* MDCXX. Oxonii, . . . 1621.

¹²Cajori represents (*History of Elementary Mathematics*, New York, 1897, p. 281) that the above mentioned lectures were delivered "about 1570." According to this statement Savile was "sinking under the weight of years" about the time that he attained to his majority for he was born in 1549.

—for the manner in which the boys dress is determined in part by the State, etc., are here set forth.

In German, references may be given to Klein's sketch of the Teaching of Geometry in France, *Elementarmathematik vom höhern Standpunkte aus, Teil II, Geometrie*, Leipzig, 1909, pp. 456-476.

In English, the most recent article dealing with our subject is Professor G. W. Myers' "Report on the Teaching of Mathematics in France" (with its curiously inaccurate statements concerning the baccalauréat), *School Review*, September, 1911, XIX, 433-453—Professor F. E. Farrington's book *French Secondary Schools* (Longmans, 1910) contains a chapter, pages 257-287, "Mathematics and Science"; the first six pages form an historical introduction—A pleasant sketch of "Life at the Sorbonne," was given by H. Jones in the *Nation*, XCI, p. 576-577, December 15, 1910—The second edition of Barrett Wendell's "France of Today" (Constable, 1908) contains a chapter (p. 1-46) on "The Universities"; attractive in style and treatment, its value is marred by a number of misleading and incorrect statements—In March, 1900, Professor James Pierpont published in *Bulletin of the American Mathematical Society* (VI₂, 225-249) a very interesting article entitled "Mathematical Instruction in France." Although secondary education as it was before the great reform of 1902-5, is analyzed to a certain extent, the article was doubtless intended to be read more particularly by the graduate students or professors in American universities—In 1910 I presented a similar paper to the Royal Society of Canada; it is printed in the *Transactions and Proceedings* for 1910, IV₃, 89-152. Appendix A of this paper contains the programme for the *Concours* of the *Agrégation des Sciences Mathématiques* for 1910 and copies of the examination papers set in 1909. The answers expected (unofficial) to the questions in the annual agrégation examination papers, appear a few months later in *Nouvelles Annales de Mathématiques, Revue de Mathématiques Spéciales* and *Journal de Mathématiques Élémentaires*. A study of a series of such examination papers and answers soon leads to adequate appreciation of the mathematical capabilities of the agrégé or lycée professor—The programmes and examination papers for the agrégation from year to year may be purchased at Librairie Croville-Morant, Paris. In a new publication, *Annales du Baccalauréat* (Librairie Vuibert) containing 9 fascicules a year, the first and ninth fascicules give full information

with regard to the mathematical examination papers of candidates for the *Baccalauréat*.

A LIST OF MATHEMATICAL TEXT BOOKS USED IN FRENCH
SECONDARY EDUCATION.

No student of Secondary Education in France should omit the study of the text-books. Similar preparation for professors in lycées and universities, and the intimate relations between these institutions has for many years inspired French university professors to write school texts. Legendre, Clairaut, Bertrand, Boillier and Catalan are among others in earlier days, while Gour-sat, Tannery, Darboux, Hadamard, Méray and Borel are of our time. On the other hand those authors who are lycée professors are brilliant and excellently equipped mathematicians.

The ignorance of the mathematician concerning the books used in connection with elementary or secondary education of a foreign country is very general, and yet, in the case of America, at least, familiarity with works used in France would be a source of great inspiration and help not only to the vast body of text-book writers and teachers in high schools but also to professors in colleges. For, as we have seen, the mathematical student in the lycée is thoroughly conversant with those topics usually treated well on in the undergraduate course of the better American colleges, while those leaving the *Classes de Mathématiques Spéciales* at the age of 18 or 19 years are many times better equipped mathematicians than our sophomore or junior college student of 20 or 21 who has specialized in mathematics.

To refer to the books in the following list as "text-books" will not lead to any misconception when it is recalled that French professors make sparing use of books in classes, since the subject matter of the courses is usually presented by dictation or lecture.¹³ But these books are such as the pupils have used in working up the lectures, or such as a professor has encouraged the pupil to consult in the lycée library.

My selection is limited to about 35 works or courses which I have thought would be representative. Many others which would have been of interest to the American mathematician are omitted on account of space limitations. An analysis of the contents and characteristics of a number of the geometrical texts

¹³The reasons for this are clearly set forth in *Rapports*, French Sub-Committee, l. c. III. 90.

may be found in M. Th. Rousseau's report (pages 88-110) referred to above.

The arrangement is alphabetical according to authors. The date and place of publication, the name of the publisher, the number of pages, and in most cases the names of the classes for which the books were especially designed, are given.

At the end of the list I have added the names of four defunct and three current periodicals, published in the interests of French elementary and secondary mathematical education. Much of interest in this department may be gleaned from these sets.¹⁴

A number of French books (such as those by Gelin and Neuberg) by *Belgian* authors are purposely excluded from this list, although they are widely used in France. Translations of books originally written in a language other than French are also excluded; otherwise I might have listed several popular works (such as those by Alexandroff, Faifofer and Petersen).

The editions indicated in the following list are not necessarily the last published—but simply the last I have seen. The size of the works may not be judged by the number of pages only—as the formats vary from 16mo. to royal 8vo.; *e. g.* Borel's course is in 12mo. Darboux's in large 8vo.

ANTOMARI, X. Cours de géométrie descriptive (Mathématiques Spéciales) 3^e éd. Paris (Vuibert).¹⁵ 1906, 619 p.

APPELL, P. Cours de mécanique (Mathématiques Spéciales) 3^e éd., entièrement refondue Paris (G. V.).¹⁶ 1912, 527 p.

APPELL, P. AND CHAPPUIS, J. Leçons de mécanique (Mathématiques A. B.). Paris (G. V.), 2 volumes.

V. i. Notions géométrique. Cinématique. 3^e éd. 1909, 178 p.

V. ii. Dynamique et statique du point. Statique des corps solides, machines simples. 2^e éd. 1907, 240 p.

APPELL, P. See also Briot and Bouquet.

AUBERT, P. and PAPELIER, G. Exercices d'algèbre d'analyse et de trigonométrie (Mathématiques Spéciales). Paris (Vuibert), Tome i, 1908, 362 p.; Tome ii (deuxième année), 1910, 359 p.

BOREL, É AND ROYER, M. "Cours Émile Borel." Paris (Colin):—

Arithmétique (I Cycle), 1907, 220 p.

Géométrie (I, II, Cycle), 2^e éd. 1908, 383 p.

Note:—Klein (l. c) speaks of this work as "ein sehr interessantes Buch."

Algèbre (I Cycle), 2^e éd., 1905, 256 p.

Trigonométrie (II Cycle), 2^e éd., 1905, 198 p. + *Fascicule*, 1908, 11 p.

Géométrie cotée par R. Danelle, 1908, 64 p.

Algèbre (II Cycle), 3^e éd., 1905, 401 p. + *Fascicule*, 1908, 30 p.

BOURDON, P. L. M. Application de l'algèbre à la géométrie, comprenant la géométrie analytique à deux dimensions. 9^e éd., revue et annotée par G. Darboux. Paris (G. V.), 1906, 648 p. + 10 p.

¹⁴L'Enseignement Mathématique (XIV^e Année, 1912), published in Geneva, is also of value.

¹⁵Immediately after the place of publication follows the name of the publisher. The publishing house Vuibert was formerly known as "Vuibert & Nony."

¹⁶G. V.—Ganthier Villars.

BOURLET, C. Leçons d'algèbre élémentaire (Mathématiques A. B.), 5^e éd., Paris (Colin), 1907, 566 p. *Cours de Darboux*.

BOURLET, C. (i) Éléments de géométrie, plane et dans l'espace (I et II Cycles A), Paris (Hachette), 1908, 378 p. [2^e éd., 1910, vi and 383 p.]¹⁷

(ii) Corrigés des 773 exercices et problèmes dans les Éléments" avec collaboration de Paul Baudoin, Paris (Hachette), 1908, 348 p.

BOURLET, C. Cours abrégé de géométrie—avec nombreux exercices théoriques et pratiques et des applications au dessin géométriques avec the collaboration de M. P. Baudoin, Paris (Hachette):

(i) Géométrie plane (VI, V, IV, B), 4^e éd., 1909, 408 p.

(ia) Corrigés des exercices théoriques, 1908, 302 p.

(ii) Géométrie dans l'espace (III B), 3^e éd., 1911, viii+239 p.

(iia) Corrigés des exercices théoriques, 1908, 172 p.

BOURLET, C. Leçons de trigonométrie rectiligne (Mathématiques A. B.), 3^e éd., Paris (Colin), 1908, 322 p. *Cours de Darboux*.

BRIOT, CH. Leçons d'algèbre. 2^e partie revue par É. Goursat, 18^e éd. (Mathématiques Spéciales), Paris (Delagrave), [1906], 635 p.

BRIOT, CH. AND BOUQUET, J. C. Leçons de géométrie analytique, 15^e éd., revue et annotée par M. Appell. Paris (Delagrave), 1893, 758 p.

Note:—The sections of this work devoted to plane analytical geometry (about two-thirds of the whole work) were translated into English by J. H. Boyd in 1896 (Werner School Book Co., Chicago and New York).

DARBOUX, G. Cours couplé pour la classe de mathématique A. B., publié sous la direction de G. Darboux—See Bourlet (2), Hadamard, Tannery, Tisserand.

Note:—The title of this course is somewhat of a misnomer as the various topics are treated with an elaboration scarce possible in any lycée class outside of the Classe de Mathématiques Spéciales.

DARBOUX, G. See also Bourdon.

DUPORCQ, E. Premier principes de géométrie moderne à l'usage des élèves de Mathématiques Spéciales et des candidats à la licence et à l'agrégation. Paris (G. V.) 1899, 160 p.

F. J.¹⁸ Éléments de géométrie. Tours (Mame et Paris (Poussielgue) 1909, 523 p.

F. G. M. Exercices de géométrie comprenant l'exposé des méthodes géométriques et 2000 questions résolues. 5^e éd. Tours (Mame) et Paris (Gigord), 1912, xxiv+1298 p.

Note:—A *livre du maître* for the "Éléments." Historical notes abound and 39 pages are devoted to Indexes of various kinds.

F. J. Éléments de géométrie descriptive. Tours (Marne) et Paris (Poussielgue), 1910, 458 p.

F. G. M. Exercices de géométrie descriptive. 4^e éd. Tours (Marne) et Paris (Poussielgue), 1909, X+1099 p.

Note:—A *livre du maître* for the "Éléments." Indexes, pp. 1073-1099.

GÉOMÉTRIE. Cours supérieure, par une réunion de professeurs. Tours (Mame) et Paris (Poussielgue), [1908], 323 p.

Note:—Preparatory for F. J. Éléments de géométrie.

GRÉVY, A. Traité d'algèbre (Mathématiques A. B.), 4^e éd., Paris (Vuibert), 1908, 498 p.

¹⁷Information concerning editions I have not seen is added in this way.

¹⁸The two authors of this and the three following works are *Frères* of the *Écoles Circiennes*.

HADAMARD, J. Leçons de géométrie élémentaire (Mathématiques A, B), Paris (Colin)—*Cours de Darboux*.

Tome i: Géométrie plane, 2^e éd., 1906, 308 p.

Tome ii: Géométrie de l'espace, 1901, 582 p.

HUMBERT, É. Traité d'arithmétique (Baccalauréat et écoles du gouvernement). Avec une préface de Jules Tannery, 4^e éd., Paris (Vuibert), 1908, 496 p.

KOEHLER, J. Exercices de géométrie analytiques et de géométrie supérieure à l'usage des candidats aux École Polytechnique et Normale et à l'agrégation. Questions et solutions. Paris (G. V.) Tome i, 1886, 349 p.; tome ii, 1888, 469 p.

MÉRAY, CH. Nouveaux éléments de géométrie. Nouv. éd. refondue et augmentée. Dijon (Jobard), 1903, 450 p.+22 pl. [3^e éd., 1906.]

Note:—Klein (l. c.) devotes more than a page to this highly interesting work of which perhaps the most prominent characteristics are treatment based on the idea of motion and the fusion of planimetry and stereometry from the very first. M. Rousseau gives up over five pages of his report to the discussion of Méray's book.

NIWENGLOWSKI, B. Cours de géométrie analytique (Mathématiques Spéciales). Paris (G. V.), 3 tomes. Tome i: 2^e éd., 1911, vi+496 p.; tome ii: Constructions des courbes planes, complément relatifs aux coniques, 2^e éd., 1911, iv+324 p.; tome III: géométrie dans l'espace avec une note de É. Borel sur les transformations en géométrie, 1896, 572 p.

NIWENGLOWSKI, B. Cours d'algèbre (Mathématiques Spéciales), Paris (Colin), 2 tomes et supplément. Tome i, 5^e éd., 1902, 391 p.; Tome ii, 5^e éd., 1902, 488 p.; supplément, 1904, 43 p.

PAPELIER, G. Précis de géométrie analytique (Mathématiques Spéciales), Paris (Vuibert), 1907, 696 p.

Note:—Pages 431-696, 3 dimensions.

ROUCHÉ, É. et COMBEROUSSE, CH. DE. Éléments de géométrie suivis d'un complément à l'usage des élèves de mathématiques élémentaires et de mathématiques spéciales, etc., 7^e éd. Paris (G. V.), 1904, 651 p.

ROUCHÉ, É. et COMBEROUSSE, CH. DE. Traité de géométrie. 7^e éd., Paris (G. V.), 1900. Tome i: géométrie plane, 548 p.; tome ii: géométrie dans l'espace, 664 p.

ROYER, M. See Borel, É.

SERRET, J. A. Traité de trigonometrie. 9^e éd., Paris (G. V.), 1908, 336 p.

TANNERY, JULES. Leçons d'arithmétique théorique et pratique (Mathématiques A, B), 2^e éd., Paris (Colin), 1911, xvi+545 p. *Cours de Darboux*.

TANNERY, J. Notions de mathématiques avec notions historiques par Paul Tannery, 3^e éd., augmentée de notions d'astronomie (Programmes du 1902 et 1905—Classe de philosophie), Paris (Delagrave), 1905, 370 p.

TANNERY, J. Leçons d'algèbre et d'analyse (Mathématiques Spéciales), Paris (G. V.), 1906; tome i, 423 p.; tome ii, 636 p.

TANNERY, J. See also Humbert, É.

TANNERY, P. See Tannery J.

TISSERAND AND ANDOYER. Leçons de Cosmographie (Mathématiques A. B.), Paris (Colin), 1909, 371 p.+12 pl. *Cours de Darboux*.

VACQUANT, CH. AND MACÉ DE LEPINAY. Cours de trigonometrie. Paris (Masson). Première Partie (Classes C, D et Mathématiques, A. B). Nouv. éd., 1909, 294 p. Deuxième Partie (Mathématiques Spéciales). Nouv. éd., 1909, 172 p.

L'Education Mathématique publié par A. Durand et H. Vuibert XIV^e année, 1911-1912 (Vuibert), 20 numbers a year.

Note:—Very elementary.

Journal de Mathématiques Élémentaires publié par H. Vuibert, XXXVI^e Année, 1911-1912 (Vuibert), 20 numbers a year.

Revue de Mathématiques Spéciales redigée par É. Humbert, G. papelier, P. Aubert, P. Lemaire, C. Rivière, H. Vuibert, XXII^e année, 1911-1912 (Vuibert), 10 numbers a year.

Note:—The solutions of the more elementary portions of the examinations for the agrégation are published each year in these last two mentioned periodicals.

Bulletin de Mathématiques Élémentaires dirigée par M. Ch. Michel. Octobre, 1895—Juillet, 1910 (Lemarre).

Bulletin de Mathématiques Spéciales redigée par Niewenglowski at de Longchamps, Octobre, 1894—Juillet, 1900 (Lamarre).

Journal de Mathématiques Élémentaires redigée par Bourlet, de Longchamps, G. Mariaud. Octobre, 1876—Mai, 1901 (Delagrave).

Journal de Mathématiques Spéciales redigée par de Longchamps Mariaud. Octobre, 1879—Mai, 1901 (Delagrave).

COAL "WASTE."

The production of anthracite in Pennsylvania includes an appreciable quantity of usable fuel recovered from the old culm banks by washeries, and the unsightly monuments to the wasteful methods of early times are disappearing from the landscape in the anthracite region. The quantity of coal recovered in the 22 years since the first washery was constructed in 1890 has amounted to about 50,000,000 long tons, considerably more than the total production of anthracite at the beginning of the period. In 1911, the washery product amounted to 4,136,044 long tons. In addition to the coal recovered from the culm banks, 94,647 long tons in 1911, and 91,833 tons in 1910, were recovered from the bottom of Susquehanna River by dredges.

In the bituminous regions the principal use of washeries is to improve the quality of the slack coal used in the manufacture of coke by reducing the ash and sulphur, although considerable quantities, particularly in Illinois, are washed in the preparation of sized coal for household use. The quantity of bituminous coal washed at the mines in 1911 was 12,543,114 short tons. The washeries yielded 10,999,481 tons of cleaned coal and 1,543,633 tons of refuse.

PEDAGOGY IN TRIGONOMETRY.

BY ARTHUR LATHAM BAKER, PH. D.,

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The text books in trigonometry seem to consider that the only requirement called for is to supply the student with the facts (equations) and a logical proof of their correctness. They seem to ignore entirely the pedagogy of the subject, the inducing the student to derive his equations with an intelligent predetermination of procedure and prevision of process. They seem to have overlooked completely the requirement of Ufer in his *Pedagogy of Herbart*, "*The pupil must know from the beginning what is aimed at, if he is to employ his whole energy in the effort of learning.*"

Instead, they supply a bald chain of sequences without a hint as to why that particular line of sequences was adopted. As far as the inquisitive student is concerned, it is

"His not to reason why,
His but to do and die."

A glaring illustration of this is found in the summation equations, $\sin (x+y)$, etc.

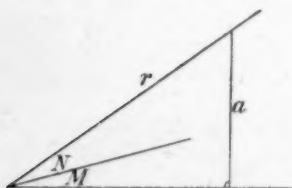
As a matter of pedagogy the student should not be allowed to make a single move without being able to give a clear and pre-determined reason based upon the facilities which have been antecedently provided and entirely independent of any antecedent knowledge of the answer.

For example: Having the functions of the angle M and N , \sin , \cos , etc., to find $\sin (M+N)$. The question is,

$$\sin (M+N) = ?$$

How are we going to get across the equation sign? So far we have only one tool at hand, viz., the goniometric definition.

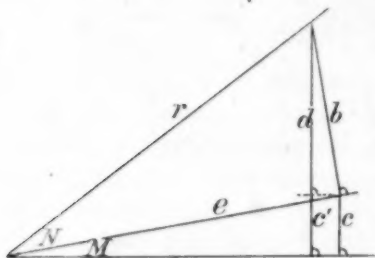
But this requires that the angle $(M+N)$ shall be in a right triangle. Hence we draw the line a as shown,¹ *anywhere*, solely for the purpose of getting $(M+N)$ into a right triangle, in order that we may use the definition, and write,



$$\sin (M+N) = \frac{a}{r}$$

¹The small quadrant shows the right angle.

But this does not answer our question, notwithstanding that we are across the equation sign. We are across the equation sign, but the answer found there is not in terms of the data: a has nothing to do with the given angles, M or N , though r might have. Hence the next step is to secure lines (and right triangles) which do refer to M and N , and we draw the lines b , c , making



right triangles containing the component angles M and N , the small quadrants indicating the right angles. Does this help any? Not yet, because there is no connection between a , b , c . Therefore the next step is to break up a into $d + c' = d + c$, as shown, thus partially connecting a

with sides of right triangles referring to at least one of the component angles, M . It looks now as if we might be balked, until by utilization of the 3 F 's (see *SCHOOL SCIENCE AND MATHEMATICS*, Vol. 12, 1912, p. 302) we find that $\angle dh = \angle M$. And now our equation takes the form,

$$\begin{aligned} (1) \quad \sin (M+N) &= \frac{a}{r} \\ (2) \quad &= \frac{d}{r} + \frac{c}{r}, \\ (3) \quad &= \frac{b \cos M}{r} + \frac{c}{r}, \\ (4) \quad &= \sin N \cos M + \frac{c}{r}, \end{aligned}$$

and we have made a long step toward the answer, because now all our lines refer to the component angles. But the terms of our answer still lack some essentials. The answer is in ratios, and in ratios between the sides of right triangles, and between sides of right triangles relating to the component angles, but (alack) not in ratios between sides of the *same* right angle triangles. The sides c and r belong to two different triangles whose common side is e . Hence changing the ratio $\frac{c}{r}$ into

$$\frac{c}{e} \cdot \frac{e}{r}$$

(which does not change its value) satisfies this last requirement, and our equation becomes

$$\begin{aligned}
 (5) \quad \sin (M+N) &= \sin N \cos M + \frac{c}{e} \cdot \frac{e}{r}, \\
 &= \sin N \cos M + \sin M \cos N,
 \end{aligned}$$

and our goal has been reached.

Why was equation (1) written?

To get an *equation* (by means of the definition), an equation being the first requisite for discussion, and the definition being the *only* tool at hand.

Why was equation (2) written?

Neither a nor r belong to right triangles containing the component angles, M and N , and therefore b is drawn to throw r into a right triangle containing a component triangle. c was drawn for a similar reason, viz., to get a triangle containing the component angle, and at the same time to be able to break up a into its parts, $d+c$, as shown in the diagram. We now have ratios, not only that, but ratios between sides of right triangles, and moreover triangles which contain the component angles.

Why was line $d+c$ drawn? In order to get $(M+N)$ into a right triangle so as to apply the definition and get an equation, a starting point for our work.

Why were the lines b and c drawn? (See above.)

Why were eqs. (3) and (4) written?

Why was eq. (5) written?

When the student can answer these questions with reasons which are independent of the guidance of a look ahead at the answer, and of the dictation of the text he is being educated for power and individuality. Without these questions and answers his class room work is instruction only, not education.

ON THE PSYCHOLOGY OF ERRORS IN ELEMENTARY MATHEMATICS.¹

By THOMAS J. McCORMACK,
La Salle, Illinois.

The psychology of the errors committed in elementary mathematics involves the consideration of two complementary processes: the one, a mechanical or physical act, which leads to a result that does not tally with reality and which is the palpable embodiment of the error; and the other, the mental or psychical operation that accompanies or initiates the false mechanical procedure. Thinking, by mathematical concepts, is a reaction-activity. The name, concept, rule, or definition evokes the attendant images or memories that form its content, and the word or concept becomes flesh, assuming the physical form that our will or intellectual habitudes give it. The concept or definition "square" automatically evokes in the mind, or impels the pencil to construct, a four-sided figure with one right angle. The psychical stimulus determines as its complement a physical reaction. Every idea has a dynamic constituent which automatically causes it to assume physical shape, whether that shape is a mirrored image in the mind, a significant sound in air, or a symbolic group of marks on paper. All the physical acts that went to the birth of the idea are re-evoked through intellectual habit and association when that idea or psychical complex is re-stimulated or when any constituent part of it is re-stimulated. The merest excitation will unlock its stored dynamic treasures, and if the psychical and physical drill that created it was exact and thorough, the forms which it assumes on reviviscence will be flawless in their congruence with reality; there will be an exact, one-to-one cor-

¹Paper read before the Mathematics Section of the High School Conference at the University of Illinois, Friday, Nov. 22, 1912.

The suggestions to the ideas contained in the following paper, which is intended as a contribution only to the psychology of error and may be followed by a more detailed exposition, are drawn from a wide range of philosophical and mathematical reading. The main psychological ideas have been developed in Mach's works, notably his *Analysis of the Sensations*, and in the sources there mentioned. Some of the cuts in this paper also are taken from Mach's works, where the notion of science as an economy of thought has found full exposition. (See Mach's *Mechanics*, *passim*.) Nearly all these books may be had in English translations from The Open Court Publishing Co., of Chicago.

Students of method in science may be referred to Duhamel's "Des Méthodes dans les Sciences de Raisonnement" (Paris: Gauthier-Villars, 2nd éd., 1882), to Jevons's "Principles of Science" (London: Macmillan, 1900), to Poincaré's "La Science et l'Hypothèse" (Paris: Flammarion), and to numerous recent articles in the French and German metaphysical reviews. Philosophical readers will find some points of contact in M. Renouvier's works (See the *Critique philosophique*, 1879, p. 370 et seq.); while students interested in the psychology of symmetry from the aesthetic and musical side will find interesting material in Sorel's beautiful book, "Des conditions physiques de la Perception du Beau" (Geneva, H. Georg, 1892). The article on "Symbols and Notation" by De Morgan in the old English Cyclopædia will also be found helpful.

respondence between the psychical and the physical process, between the thought and the reality. There will be freedom from error.

I have taken as my type here of mathematical thought the simplest possible case—the translation of a concept, namely, the definition of a square, into physical reality. If it is required to prove that in such a figure all the angles are right angles, then it is necessary to translate into physical or quasi-physical images a *number* of concepts concerning triangles and the congruence of triangles—which images, if correct, will by virtue of the properties inherent in them, automatically coalesce into a new composite image, which, translated back into psychical terms, will give the judgment that is the solution. But with this automatic coalescence, which involves the whole psychology of reasoning, I am not now concerned. I will assume the correctness of the mechanism of coalescence if the individual translations are correct, and restrict my attention in this paper largely to the conditions that determine the correct translation, finding the errors that we seek in part in the obstacles that present themselves to this translation.

THE PROCESSES OF REASONING AND CONFUSION ALLIED.

A few preliminary words, however, may be necessary on the nature of reasoning generally as distinguished from mathematical reasoning proper, if it is only to make our point of view clear. For it will be our object to show that error or confusion springs from the same source as truth. Confusion and reasoning are allied species of the same genus of psychological procedure. Reasoning proceeds both in the unconscious and conscious realms by the fusion of images, percepts or concepts, through the laws of association by resemblance or contiguity, into new images, percepts or concepts. The attraction or substitution takes place because of the similarity of parts. We substitute a *part* for a whole, or make two things that are only in part identical, identical as wholes. The impulsion is inevitable. Resemblance, similarity, analogy are the parents and guides of truth, but they are likewise a fertile source of confusion.

Any similarity evokes by association the concept and hence the name, and so may disengage a wrong reaction-activity. A child calls every four-footed animal a dog; later, every rectangle a square, or a square an oblong, or even a cube a square, and a sphere a circle. The phrase or direction to "square the number

three" disengages a multiplication-activity which just as often produces "twice three" as it does "three, twice as a factor."

When the word or concept disengages a *number* of sense-operations, the liability to error is correspondingly greater. When I hear the word triangle, a definite image appears before my mind's eye; so, with a square. But if I hear the word heptagon I can only with difficulty bring the sensuous fact before my mind, and, to do so, I must count, I must perform a sense-operation, which, when I hear the word "icosahedron" is heightened greatly in difficulty. Every person possesses the concept and knows the word "cube"; yet ask an average man how many faces, not to say edges, a cube has, and you will be astonished at the difficulty with which the sense-operations necessary to an answer are performed.

It follows from this that it is necessary not only to possess the concept, the word, the rule, but also to have performed repeatedly all the sense-operations of counting and visualizing that the word or rule involves. When this is done, in other words, when the drill or the practice is perfect,—then the reaction-activities involved in the word or rule are released automatically, at the mention or sight of it, and are performed with mechanical precision.

It is an inverted criticism to say that a child applies a rule "mechanically" and "unthinkingly." The criticism should be, he applies it "unmechanically and thinkingly"; for when we do not possess a rule or formula in all its content, then truly do we have to think and struggle from sheer terror of error. Only when the rule is fixed deep and firm, only when its action in all its implications is mechanical and automatic, is error precluded. Mechanism is the last word of mathematics, so far as practice and instruction are concerned. "It thinks,"* not "I think" is the goal and ideal of science. It should be the motto of mathematics teachers: "Let the formula, not George, do it."

NATURE OF THE ERRORS CONSIDERED.

A close scrutiny of the description of thinking that I gave at the outset of these remarks will show that error may arise in our thinking in three ways: (1) through the imperfect formation or architecture of the concept, rule, or definition; (2) through the imperfect embedment of the concept in the psychical structures of the mind (improper or imperfect presentment, drill

*Quoted from Lichtenberg, an eighteenth century German physicist.

and practice); and (3) through a hitch or kink in the passage or unravelment of the psychical complex, the concept, into its proper physical counterpart, the "development," or the "answer."

With the first source of error we are not, as teachers, immediately concerned. Mathematics is a finished science; its concepts and definitions are reversible; the physical reaction incident upon the definition of a square gives a square and nothing else; the psychical reaction incident upon the envisagement of a physical square gives the mathematical definition of a square and no other definition. The problems here involved are problems of the psychology of judgment; they may give rise to errors, but they are the errors of the architect and not of the stone-mason. They do not concern us as pedagogues.

But with the second class of errors, those connected with the embedment of the concepts in the mind, and with the third class, the automatic disengagement of the concepts from the mind into their appropriate physical reactions either as spoken words or as marks on paper called solutions and answers to problems and exercises, we are concerned deeply. For this constitutes the psychology and the method of pedagogy; first, how to put them properly and securely in; and, secondly, how to cause them to come accurately and automatically out.

It will be impossible to isolate perfectly all the processes we shall here consider. "Errors of reasoning" which we shall endeavor to eschew, are not always separable from "errors of procedure" which are our immediate object of inquiry. In explaining how mathematical thought is translated or mis-translated into mathematical action, we cannot help giving some small share of our attention to the nature and architecture of that thought itself, or even to that of scientific method generally, which is indissolubly linked with the processes with which we are here engaged.

ON THE FIXATION OF THE CONCEPTS IN THE MIND.

With regard to the embedment or fixation of the mathematical concepts in the psychical structures of the mind, which is a question of method in pedagogy, we are all pretty well agreed that its success depends upon the proper selection and presentation of the concepts, and upon a proper amount of drill with their physical reactions, whether by spoken words, marks on paper, or envisaged images in the laboratory of the imagination. (If the presentation depends upon a genetic connexion between

the concepts, so much the better; the fixation then takes place not only through drill, but through a spontaneous organic movement of the concepts themselves.) But what "proper" presentation is and what exact amount of drill is necessary, what preponderance should be given to drill and what to presentation we are not agreed; if we were, there would be fewer text-books and fewer conferences.

The reception of mathematical truths and concepts by the normal mind is a psychological process and is conditioned upon the idiosyncrasies of our mental and physiological structure. It is bound up with an intricate complexus of physiological and psychical operations; and the pedagogic trick is to discover and to utilize these idiosyncrasies, to *sap* and to open the channels of communication, to render the paths of introduction free from hindrance and obstacle. Such a utilization is commonly termed a natural or genetic method. It inserts the truth through natural paths, takes usually the routes of historical discovery, and avoids the impediments presented by sense and the barriers of our psychical and physiological make-up. It is hardly conscious of the reasons of its operations, sometimes calls itself the psychological method in contrast to the logical method, but rarely examines its procedure. It knows, however, that the process by which mathematical truth is inculcated and imbedded so as to produce correct automatic reactions, is not the process by which the finished mathematical structure is logically justified to the mature scientific mind. It has lost its faith in the Euclidean Gods of Egypt, but it has as yet found no new psychologic Moses that will substitute the commandments of nature for the axioms of the Midianite.

It will be our first task, therefore, to show what some of those peculiarities of physiological sense-structure are that facilitate or hinder the introduction of mathematical truths into the mind, and to draw the appropriate lessons from them as to the source of our strength and our difficulties in securing the proper embedment of mathematical concepts. And first as to geometry.

PHYSICAL SYMMETRY.

The psychology of symmetry will form the starting point of our investigations. Figures are primarily recognized as congruent or the same by *an act of sense* and not by *an act of intellect*. Our sensations of space, through which such recognition is effected, are determined partly by the spatial character and

configuration of our physiological sense-organs. Geometrically and intellectually the two squares exhibited in Figure 1 are

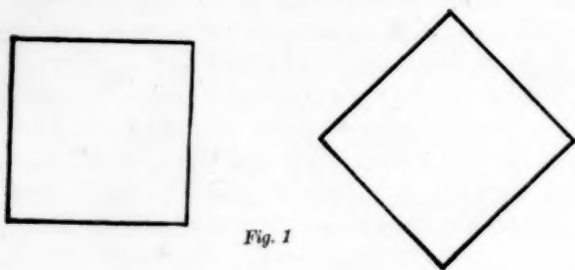


Fig. 1

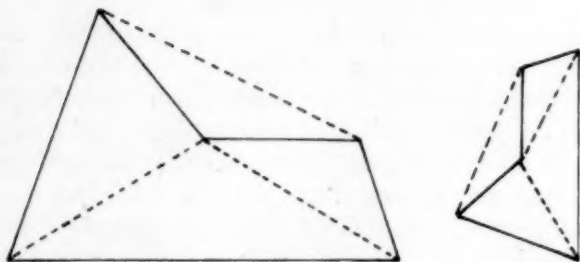


Fig. 2

congruent, but physiologically they are unlike, and they neither produce space-sensations of identity, nor do they initially evoke intellectual associations which are likely to lead to judgments of identity. The source of error, or rather the obstacle to progress in the acquisition of geometrical truth, involved in this simple fact, will be apparent to every teacher of geometry. The teachings of sense are here in glaring conflict with the facts of the logical system of geometric truths. To recognize that the two squares in question are congruent, a mechanical or intellectual operation is necessary.

The same remarks hold true with respect to geometrically similar figures, which are not optically similar unless properly placed. (See Figure 2.)

Ordinarily, at the beginning of geometrical instruction, the device to which we have recourse for putting our material within direct reach of sense-recognition is mechanical, and the operation is either effected beforehand in the text-book or on the black-board by the placing of the figure in the requisite spatial position, or, if it is not so placed, by directing the student to change in space or in thought his plane of orientation or his physiological plane of symmetry.

This will need a few words of explanation. The direct sense-recognition of congruence of which we speak is determined by the spatial character of our physiological organs of sense. Biologically the human organism has been developed under the influences of gravity; and the human body is for physical reasons necessarily symmetrical, not only with respect to its mechanical functions, but also with respect to its organs of sense. The right hand is symmetrical to the left; hence the symmetry of our sense of touch. The right eye is symmetrical to the left; hence the symmetry of our physical vision with respect to the median plane of the body. Let us say that bodies symmetrical with respect to a vertical axis possess "vertical symmetry" and that those symmetrical with respect to a horizontal axis possess "horizontal symmetry." We may now affirm that just as the apparatus of vision exhibits in space only a vertical symmetry with respect to the median plane of the head, so the sensations of space excited in us by our visual apparatus favor only the recognition of vertical geometrical symmetry. Horizontal symmetry, or symmetry above and below a horizontal line, is not directly cognized by the visual sense. The vertical symmetry of the two irregular spots shown in Figure 3 is immediately recognized by



Fig. 3



Fig. 4



Fig. 5

sense. The geometrical horizontal symmetry of the spots in Figures 4 and 5 is not directly recognized, but requires for its recognition either a mechanical act of rotation or an intellectual, logical act.

But the gradations between similarity or likeness and identity or congruence are subtle and illusive in their continuity. The operations of the organs of sense have not the same sharpness of definition as have the acts of the intellect, and the shadowy and shifting associations which pure sensations carry with them do not possess a one-to-one correspondence with the precise activities of the logical faculty. Our sensations, as determined by our physiological sense-organs, carry with them a momentum of suggestion which constantly overleaps the truth and so leads to error. In plane geometry symmetrical figures are also congruent. But neither the figures nor the sensations are identical. In the sense-judgment performed, we really jump from similarity to identity. Impressions of similarity based on likeness of sensation (as in the case of symmetrical triangles on a sphere), lead, by a species of sensory momentum, to impressions and convictions of identity. Confusion or error in this realm is the identifying of things that excite in us *similar* sensations. By the physical constitution of our organs of perception, similar impressions are excited by what may be termed symmetrical sensations; and these similar impressions are readily converted into impressions of identity.

On the other hand, these symmetrical sensations are themselves further limited in their legitimate efficacy in the case of sight by the fact that our organs of vision (and hence our sense-impressions), are physically symmetrical only with respect to a vertical plane of symmetry and not with respect to a horizontal plane of symmetry. These symmetrical sensations, therefore, are not only a source of error, as well as truth, in geometrical judgment, but they also sometimes form an obstacle to the direct recognition of actual geometrical truth. Children always confuse the letters "d" and "b" and the letters "q" and "p" which are vertically symmetrical. They never confuse the letters "d" and "q" nor "b" and "p" which are congruent geometrically but which require for their recognition or super-position a mechanical act of rotation either of the letters or of the child. We do not recognize, from behind, the face of a person lying on a couch. The reflection of a landscape in a river seen from a passing train, the reflection of a tree in water, excite no sensations of symmetry, and hence are not only never confounded, but are rarely directly discovered to be the same. The two parts of Figure 5 are not forthwith recognized as congenent.

In the motor domain this sense-confusion due to the physical

symmetry of our motor organs is strikingly evident. We always turn a screw or wrench in the wrong direction with our left hand. I myself frequently write on the blackboard the figure "3" for the letter "c."* The symmetrical movement which it is our first impulse to make and which the structure of our organs determines, is the wrong movement. It requires an intellectual act, the interposition of a conscious judgment, of an act of volition, to secure the appropriate adaptation of the motor acts to the case in question, and it requires a similar intellectual or volitional act to check the momentum of suggestion of our symmetrical sensations in the field of pure geometry. The sensory automatism here works to the detriment as well as to the advantage of the truth.

Remembering that vertical symmetry may thus lead to confusion as well as to truth and that horizontal symmetry fails to give us direct knowledge of congruence or similarity where such actually exists geometrically, it will be found that we have here two complementary or converse aspects of an important truth, namely, that the same physio-psychological conditions in the one case lead to the sense-inference of an identity that does not exist, and in the other, bar us from the sense-recognition of an identity that does exist.

An immense field for practical pedagogical research is here opened, one which has found splendid applications in aesthetics and music and one at the details of which only I can hint, leaving the developments for your further study. I will merely remark in summary that much of the error with which we wrestle in teaching elementary geometry arises from the fact that physiological space or the space of our senses with all its automatic reactions is entirely different in its structure from the geometrical space of Euclid and especially from that of the more etherealized geometry of the moderns. We feel directly (a fact which geometry does not need to recognize) the difference between "leftness" and "rightness" and "upness" and "downness," a feeling which has been preserved in the Cartesian system of geometry, but which it is really unnecessary to retain from a purely mathematical point of view. The simplest experiments will show that the space in which we live and which we feel, is utterly different from the space of geometry and resembles more the space of the hyper-geometers than it does that of Euclid. Hold a cane

*It is only in the last few days that I have seen two signs "For Sale" in which the "S" was reversed.

or a long pencil horizontally across your eye-brows and just above the nose and the cane will appear distinctly bent. Our physiological space therefore possesses a curvature not unlike that of the space of the metageometricians. Every teacher knows that the space of three dimensions, or of solid geometry, in which we actually live and of which we have an infinite amount of ancestral and individual experience, is not nearly as familiar to us as the space of two dimensions or of plane geometry, which is an abstract and fictitious space and which finds no correlates or analogues in our physiological organism. One of the most difficult things in solid geometry is the illustrating of the differences of symmetrical bodies, despite the fact that we have on our own person, namely, in our hands and feet, our eyes and ears, and in all our articles of clothing objects which possess, in the most obtrusive form, all the properties of spatial geometric symmetry. Familiarity breeds not only contempt but also error. And one of the physiological sources of this error is similarity of sensation culminating in the illusive perception of identity as induced by the symmetric innervations of our organs of perception. (The sequence is: symmetry, similarity, assumed identity, and error. The converse sequence is: absence of symmetry in our space-sensations due to the non-symmetry of our sense-organs, thence an entire absence of similar sensation, and thereupon a failure to recognize real geometrical congruence or identity.)

Let us look at some examples which will show how the textbook writer and the teacher take cognizance of the structure of our sense-organs.

PEDAGOGICAL APPLICATIONS.

The physiological conditions which we first adduced, have determined for all time the didactic position of the isosceles triangle in the text-books and in elementary instruction. No teacher or writer would have the temerity to construct his first isosceles triangle with the axis of the triangle in either an oblique or a horizontal position. In so doing he would lose utterly that "support of sense," that immediacy of intuition, which is the main-stay and the prop of all effective elementary instruction. It is true that authors and teachers who desire to test the intellectual success of their instruction purposely place figures in unsymmetrical positions. But this procedure has a different object. It is true also that many text-books arbitrarily place figures

whose congruence is to be proved in unsymmetrical positions. But the problem here is rather to emphasize the intellectual character of the congruence, to make it clear once for all that sense-congruence is not what we wish to teach and so to preclude the future possibilities of error on this score. Such authors endeavor to kill two pedagogic birds with one stone. The ease with which pupils discover the truth of a proposition through the accidents of sense, becomes a source of error or rather of non-recognition when the spatial placing of the figures is changed. To avoid the possibility of such error, the authors and teachers referred to, sacrifice ease of presentation and immediacy of intuition to the securing of intellectual certainty for all future time. The success of the procedure depends upon the pupil and upon the skill of the teacher. It is not the natural order, and a more fruitful method might be the gradual continuous changing of the spatial position of the figures,—a process which all good teachers adopt. In recent German text-books, the conflicting facts of physiological and geometrical symmetry are reconciled by mechanical operations, and in the process the figures are brought into congruence by a prescribed set of rotations and revolutions about centers and axes of symmetry based on appropriate postulates.

The typical geometric forms for purposes of elementary instruction are thus grouped by a physiological necessity around vertical lines and planes of symmetry. These are the types determined by the symmetry of our body, and instruction is easiest conducted in this position, in which sense supports intellect. This fact, therefore, is of the utmost didactic importance.

How deep this physiological necessity goes is unnecessary here to discuss. I will simply remark that from my own experience, I never could solve a geometrical problem in bed when lying on my side, but was obliged even for the intellectual envisagement of the figure to lie on my back. It seemed as if gravity pulled my thoughts as well as the figure out of geometrical gear. There was a distinct intellectual sag corresponding to the physiological sag.

Where the intellect must overcome, by an effort of will, psycho-physiological obstacles, there is always danger of error, or rather there is a drag on the process of the discovery of truth. But any variation from the conditions determined by the physiology of our organs does require intellectual effort, and intel-

lectual effort may breed confusion. Wherever we leave the terra-firma of sense, our operations are removed from the corrective checks of experience. The farther we depart from the solid domain of sense, of mechanical operations, or of visualizable mechanisms, the more does the liability to error increase. We all know that a slight mistake in the handling of logarithms involves an error and a divergence from the arithmetical facts, which is altogether out of proportion to the original mistake.

(Continued in the March Issue.)

PRIVATE LANDS IN YOSEMITE NATIONAL PARK.

That all the private holdings in the Yosemite National Park be acquired by the Government is one of the recommendations made by the superintendent of the park in his annual report which has just been made public by the Department of the Interior. "There are approximately 20,000 acres of these lands," says Lieut. Col. Forsyth, "consisting of timber claims and a few claims that were taken up under the homestead act and were never occupied as homesteads, but simply used as a pretext for bringing in stock or cattle to stray upon the park lands. There are no persons now residing on patented lands within the park, except Mr. Kibby, at Lake Eleanor.

"The timber claims are valuable and are increasing in value very rapidly. Perhaps the finest sugar-pine timber in California lies within the park along the road from Wawona to Chinquapin, and most of it is on patented lands.

"The Yosemite Lumber Co. has built a logging railroad from El Portal to near the park boundary in the vicinity of Chinquapin, and is now cutting timber there and shipping the logs to Merced Falls, where it has built a large sawmill. This company has also surveyed a route for continuing the logging railroad through the park to Alder Creek, where it claims the ownership of 6,000 acres of timber lands. The work of denudation in the vicinity of Chinquapin has already begun, and it is what will happen to the timber on all the patented lands in the park in the near future unless they are purchased by the Government.

"This matter demands urgent attention. The necessity of preserving the forest in this portion of the park and of reducing the number of private claims to such an extent as would justify the Federal Government in purchasing the remaining claims was one of the main reasons that caused the Yosemite Commission of 1904 to recommend the reduction of the area of the park.

"That commission, as has every other person who has been charged with the welfare of the park or with making any recommendations in regard to it, recommended that the Government immediately purchase and extinguish all private rights."

CHEMISTRY FOR HIGH SCHOOL GIRLS.

BY G. ROSS ROBERTSON,

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It has almost become a platitude to remark that the modern aim of secondary subjects is to place increasing emphasis on so-called "humanism," or the relation to the life of the pupil. Science teachers need not be told of the beneficial result of this doctrine. The physics text books of today do not trouble the high school boy as a general rule with such topics as the refraction of sound, modulus of elasticity and obsolete galvanic cells. In the electrical laboratory the voltmeter is supplanting the traditional galvanometer. As the same progress continues, we shall no doubt be able to spare a little space from the chapters on static electricity for the benefit of the induction motor.

In chemistry the present aim seems in large measure the introduction of manufacturing methods as an effort to humanize the subject. But all this is for the boy, and not the girl. Shall we say that whatever seems best fitted for the boy will at the same time invariably suit the girl?

First consider the teacher. In the majority of cases a man, the science teacher handles the subject from a man's standpoint. He had a special intellectual interest in school science when he took it in high school himself—an interest that was not always shared by the majority of his classmates. His college point of view is not always in accord with the pupil who has no college ambitions. It is thus no wonder that the real interests of the girl are largely subordinated in high school chemistry.

Secondly, consider the girl in science study. Girls are alternately praised and discredited for their work in school science. Praised because they have much more patience and faithfulness than the boy; because their work is by far the neater in comparison. They are gently laughed at, if not condemned, because they "haven't a scientific mind." "They cannot grasp mathematical science, cannot do scientific reasoning," etc., etc.; so goes the familiar talk.

After having listened to such a disparagement of the mental workings of a girl, one naturally questions some chemistry teacher only to be informed that the girls are by no means inferior. He will often rate them distinctly above their boy classmates in scholarship. Certainly, we say; let the boys enliven the discussion from day to day in *boys'* chemistry, and your faithful

girls will be entirely too proud and too conscientious to fall behind. Here lies the big argument for co-education—let one sex profit by the experiences, remarks, discussion, reasoning of the opposite sex. But to go back: the inference still characterizes the girl as a good learner, memorizer, but as a poor reasoner. Is this just?

It is time that we stop calling the girl's mind unreasoning and merely emotional. Emotional it may be, but emotions do not pass in psychology as a mathematical substitute for reason. And yet it is still true that the high school girl fails to reason as does her brother. Her excuse is not physiological, for we are told that the girl develops first. The excuse, or rather the blame, lies in the subject matter she is trying to study. She has no interest, and has no reason to be interested in half of the material she meets in high school chemistry. What does she care about the workings of a sulphuric acid plant, or a fertilizer factory? These phases of modern chemistry should by all means be handled in the chemistry course—for boys. With girls their value is certainly questionable. But why continue the infliction of extraneous material on the girl merely because she is faithful, uncomplaining and more industrious in routine work?

The logical conclusion of this sort of argument means of course the segregation of sexes in science classes. In some cities this is now coming to mean the splitting apart of the entire school despite great expense. In others the segregation of science classes alone can be made. Any school having enough pupils to make two divisions in chemistry can segregate the sexes if the principal only thinks so. Program conflicts need not preclude the plan, though temporary difficulties arise. The move must of course be justified by some concrete benefit.

Now as to text books. Writers have felt the movement, and to meet it have produced several books, none of which can in any measure be called a high school chemistry text for girls. Here and there some small manual of a few experiments, or a diluted, general science, "low-pressure" variety of chemistry supposed to be suitable for girls. Or on the other hand, one can find all sorts of really good material, but scattered over half a library. Here a little treatise on pure foods, there a discussion of sanitary chemistry or household methods, but in no case is there a real "from-the-ground-up" text suited to girls' interests and needs. When we break away from the traditional masculine chemistry, it will never do to throw everything overboard

and then confine ourselves to a brief exposition of a few knacks and tricks about the home which happen to involve a little chemistry. One principal, and the head of a girls' high school, remarked that the girls' courses must not bear the stigma of being "sissy." To be more definite, one may well ask the question as to where the details of girls' chemistry will differ from that taught to boys.

In the first place a reformer must remember that high school chemistry has not been developing for dozens of years to no good end whatever. A course in girls' chemistry, to be really creditable, to have any standing with the colleges, will retain the fundamentals of the present accepted chemistry work in large measure. Certain changes will of course occur. Less emphasis will be placed on the derivation of molecular formulas through gas laws. There is no need for the usual mass of argument and **exposition to enable the pupil** to find the amount of sodium obtainable from a pound of salt. Little permanent value comes from the parody of a girl "discovering" the formula of this or the other substance—a little stage-play in imitation of the great work of nineteenth century chemists.

This suggestion will of course draw critical fire, since it seems to discount the very foundation of recent investigation on the lines of the atomic-molecular theory. But critics often fail to realize that the so-called foundations of science are only relative. We cannot expect the high school pupil, either boy or girl, to reach the depths of chemical theory. What right, then, has **anyone to set up a certain measure of theory** as the necessary fundamental minimum? A tremendous amount of information in the high school text goes unproven on the authority of great men—yet we insist that the pupil rack her brain with the Avogadro puzzle, consult Dulong and Petit's Law which she cannot understand, etc., to prove on paper the formula of some simple compound which she could take on authority as easily as she does the theory of ionization.

The writer realizes that this doctrine alone, carried to its limit, would oust entirely all chemical theory, leaving the subject as it was in the high school texts of a few years ago—a mass of encyclopedic facts. And this too would be a greater evil. But the fact remains that we haven't time in the high school to peruse **extensive theory**, and must restrict it if any practical good, any humanizing influence is to be squeezed into the course. Let theories and principles be few and easily understood, and then

let the course stand as a constant expansion and exemplification of these principles. And after that the college will take care of the historical theories. In a girls' class, if not in a boys' class as well, we will find some day that no great crime is committed when we teach—"H plus Cl equals HCl" instead of the more ideally correct " H_2 plus Cl_2 equals 2 HCl."

There is no intention of discarding all that is thoroughly scientific. Let increasing emphasis be placed on a branch of chemistry which is really important to girls, viz. the phenomena of solution through the explanation of ionization. The examination of reversible reactions and the law of mass action; the nascent state, relation of heat to reaction, etc., will command much greater place than the historic and long-drawn exposition of Charles' and Boyle's and Avogadro's laws, vapor tension and the like.

Moreover, in the girls' course less importance will be ascribed to the metals in purely manufacturing processes. Less qualitative analysis—branch of chemistry which in a girls' class can be justified only on the much mooted ground of formal discipline. It produces interest, the element we claim to be after, but it is the interest of puzzle and curiosity only.

The chemistry material desired in this new plan of course calls for exemplification from the field of household and everyday life. It means also that organic chemistry must find a place in the girls' course. There is no need saying that organic chemistry is too hard and involved for high school pupils. There is just as much sense in saying that college inorganic chemistry is too involved for adolescents. Of course it is; but the duty now calls for someone to put elementary organic chemistry on a high school basis. There is hardly a standard high school text that does not pass over the field of organic chemistry with an utterly inadequate chapter hinting at a small part of the work.

Girls' chemistry will be of course the chemistry of everyday life, but it will not be as many imagine merely a study of the devices, ways and plans of doing things in the home. To introduce, as one book does, a series of experiments in bread and biscuit making is a questionable proposition. Lack of time alone should lead one to pass the bread experiment over to the cooking department, even if the chemistry teacher did happen to know anything in particular about cooking. The material that is to be taught, however, must have a practical as well as scientific relation to theory and fundamental principles. For example, instead of stopping with the simple fact that chlorine is a valuable

bleaching agent because of its oxidizing power, the girls' course will show why it is of such superior strength when freshly prepared in a mixture of vinegar or muriatic acid and bleaching powder such as might find use in a home. In this way the bald theory known as the "nascent state" may be clothed with an illustration which will make more impression than the conventional orthodox experiments.

Our present chemistry texts are becoming more and more replete with practical illustrations and reasonings of this sort, but the great trouble is that they are mostly for boys. For example: chromium, barium and manganese, and their uses, occupy page after page, while baking powder commands a cursory half page or a foot-note as an incidental sidelight on sodium or potassium. The homely topic of "bluing" is never mentioned in pages after pages on iron. Of course it is claimed that the exposition of the metals in the old conservative way offers the best mode of illustrating fundamentals, as well as furnishing the boys with a little technical knowledge useful in the garage, machine shop and factory. But is it not unwise to claim that these fundamentals cannot be illustrated with material which has at least some dim relation to the life of the girl?

Radical modification of the chemistry course at once invites discussion from the point of view of the college. In some cases the demand for some such course has impelled the school board to include it in the curriculum, or at least to give the plan favorable consideration. In this event the school does not even ask that the new course be accredited at the university. The intention is to run it as a free-lance proposition for those pupils who expect never to attend college. Parallel therewith is the regular course leading to college entrance.

Such a plan seems a great mistake. It has been said that whatever course prepares best for college is best for life; but some of us are beginning to see that a course primarily fitted for after life isn't bad for college entrance. The college men don't like their dogma turned end for end, but they will have to take it so as time goes on. Why put a stumbling block in the path of a future girl graduate who may wish to enter college later on, but finds difficulty in having failed to take the orthodox chemistry course? A good course can be outlined without lowering the scholarship of the college intrants, and yet be greatly modified.

For the girl who has no doubt that she will enter college and

when there take advanced chemistry, there is nothing to be said. But what a pitiful minority she is, collectively! Even such a girl, who under a newer scheme might have missed a little of Avogadro's reasoning, will find that her university professor will not fall under the misapprehension of taking this knowledge for granted. He knows better! Experience has taught him that he must cover the entire elementary field, Avogadro or no Avogadro in the high school.

In the older days, when men used to argue the question of whether or not it was worth while to educate girls, it might be reasonable to plan everything for the boys, and then let the girls stand on the side and extract whatever incidental benefit they could. But that day is over. There are more girls in high school than boys anyway, and they deserve consideration as an obvious right. The present need is a text on new lines. If there is any pupil who puts implicit faith in the text and its contents, that pupil is the high school girl. Her attachment and respect for the book is fast and firm, if not even painful. It is all very well to propose the substitution of a general study by different members of a class of various sources of the material; but the question always remains—what is the use of scattering efforts, losing unity and wandering around obstructions because of the lack of a modern text to put into the hands of the girls? Cannot some good high school teacher, or group of teachers put this in shape for publication, and emancipate the high school girl from tradition in which she has no interest and for which she has no need?

To any one sending us a copy of *School Science*, Vol 1, No. 9, February, 1902, or *School Science and Mathematics*, Vol. 6, No. 6, June, 1906, we give fifty cents cash or allow \$1.00 on subscription.

A HELIOSTAT FOR THE LECTURE ROOM.

BY WILLIAM F. RIGGE, S. J.

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A heliostat, that will hold a beam of sunlight as steady as if it came from a stereopticon fed by a self-focusing arc-lamp, is looked upon by the majority of professors of physics as ideal but quite unattainable. Such an instrument would seem to be either prohibitive on the score of cost, or impracticable, owing to the demand it would apparently make for a working knowledge of astronomy to insure its accurate adjustment and manipulation. Personal experience has convinced me that the heliostat above referred to is within the reach of every teacher of physics, if he has some mechanical skill in the use of tools and the elementary knowledge of astronomy which this article will explain in detail. On these conditions he can set up his instrument and adjust the beam of sunlight within a minute or two, without a knowledge of the correct time, or of its equation, or of the sun's declination, that is, without consulting a time piece or an almanac.

The heliostat that I have in mind has two plane mirrors, one driven by clockwork about an axis parallel to that of the earth, and sending the sun's rays in the direction of this axis upon a second and fixed mirror, which in turn reflects it in any desired direction. Such heliostats are to be found quite generally in the catalogues of dealers in physical apparatus. They are, however, only expensive and unsatisfactory toys, unless the professor has subdued them, has furnished them with the attachments presently to be mentioned, has adjusted them properly, and knows how to use them. I will distribute my remarks under five headings.

1. THE AXIS.

The axis about which the first mirror revolves, is the most essential part of the heliostat. It ought to be sufficiently strong not to bend under the weight of the mirror, and be supported at points as far apart as practicable. This precaution, although evident from the fact that the mirror cannot be held between the points of support, is sometimes absurdly violated, as it was in my own instrument, in which one point alone was supposed to be sufficient, because the gear wheel on the axis was pressed close against the dial plate. Its present axis is of steel, $\frac{5}{16}$ of an inch thick, and is supported in journals 3 inches apart, the

greatest distance I could command. Three and a half inches of the axis extend above the dial plate, $2\frac{5}{8}$ of which give firm support to the cradle that carries the movable mirror, instead of $\frac{3}{4}$ of an inch as originally constructed. The old mirrors I have replaced by ordinary good plate glass silvered on the under side as usual, the movable one being $5\frac{1}{2}$ inches in available diameter, and the fixed one measuring $6\frac{1}{2} \times 8$ inches, the dimensions and shapes being as I found them and amply sufficient for my work. The mirrors should be provided with clamps of some sort to hold them tightly against the wind.

That the axis should be exactly at right angles to the plane of its box or of its hour circle, is not absolutely necessary, but it must be elevated as accurately as possible at an angle equal to the latitude of the place. The best way to accomplish this is to apply some form of clinometer directly to the axis itself after the base has been permanently levelled, as will be mentioned later. The latitude adjustment ought then to be securely locked to prevent its accidental displacement.

2. THE MERIDIAN.

To set the axis of the heliostat in the meridian is the most difficult of its adjustments, because it calls for some astronomical skill. I have found the most convenient, and more than sufficiently accurate, method to be by means of the sun observed—the farther from the meridian the better, but not too low in the sky—by a surveyor's transit furnished with horizontal and vertical circles, but without a solar compass. The transit is set up at the same place, say the window sill, that the heliostat itself is to occupy. A thread, or better, a fine wire, is stretched across the window at a convenient height and supported by pins or tacks in the window frame in such a way that it may be replaced at any time in exactly the same position, whether the pins remain where they are or are themselves removed and replaced.

Leaving the telescope as it is whether an inverting or an erecting one, the image of the sun is focused along with that of the wires upon a piece of white cardboard held in the hand a few inches beyond the eyepiece. Having placed a watch on the sill close to the transit, a little practice will enable one to note the second when the sun's image is accurately centered, that is, bisected by both wires. To accomplish this in a satisfactory manner, it is well to clamp the horizontal circle in advance of the sun, and as its image moves to one side, to bisect it with

the horizontal wire by means of the slow motion screw of the vertical circle at the very moment when the vertical wire bisects it. One who has never tried this method might be disposed to doubt its accuracy. My experience, however, is that, when the instrument is firm, I very rarely go astray in the azimuth by the thirtieth part of the sun's diameter, that is by a minute of arc. Such accuracy is really more than is needed, in fact, more than can be of any practical use.

Five observations of this kind ought to be made in each position of the telescope, that is, in its direct and reversed position, or level-up and level-down, or vertical circle to the right and to the left. In each case after first noting and recording the time, both circles must be read to the minute. The use of a watch is not absolutely necessary, but it serves as a check upon the observations. At all events the correction to the time piece and its rate need not be known.

Then having levelled the telescope and set it three times parallel to the thread in each of its four possible positions, direct and reversed and facing each end of the thread, we take in all a dozen readings of the horizontal circle. This completes the series of observations.

As the thread can at any time be accurately replaced in the same position, we may compute the results at our leisure. But before actually beginning the computation, it is a safe precaution against gross errors to make a graphic plot of the observed data. For this purpose we take co-ordinate paper, and allowing convenient units, say 20 seconds of time and 2 minutes of arc to a millimeter, we plot the times and angles as observed, except that the observed altitudes must first be diminished by refraction.

When all the ten readings of each circle have been plotted, they must lie in the same straight line, if the observations have been taken, say, within the same half hour. An exploring thread will enable us to locate the two lines to best advantage. If one or other of the plotted observations is at some distance from the line, there is an error in the reading. If this cannot be corrected by any satisfactory explanation, it is best to reject it altogether.

For the computation we may select all or as many of the observations as we please. One in each position of the telescope is generally sufficient. The only use of the watch, I repeat, is in the plotting. If the observer is sure of his centerings and readings, he may dispense with it altogether.

In the computation we make use of spherical trigonometry. In the triangle whose vertices are the zenith, the pole and the sun, we know all the sides and want the angle at the zenith. The side from the zenith to the pole is the complement of the latitude, from the pole to the sun is the complement of the sun's declination, which must be found from a reliable almanac, while the distance from the sun to the zenith is the complement of the observed altitude corrected for refraction. Computing the angle at the zenith, which is the sun's azimuth counted from the north, we add or subtract it or its supplement to or from the observed reading for the meridian. Comparing this with the mean of the readings for the thread, we know the azimuth of the thread. In setting up the heliostat we then know what angle the vertical plane passing through its axis ought to make with the thread.

3. THE CLOCK.

The clock that is to drive the axis of the heliostat gives the least cause for worry. An ordinary one-day alarm clock with spring drive and balance wheel, without pendulum, is capable of doing the work. Another wheel must be added so as to reduce the speed to one turn a day. The jerking motion, which the balance wheel necessarily imparts, and which would be fatal for a telescope, is too minute to be noticeable in a lecture-room heliostat. There must, however, be no lost motion in the gearing, and the centre of gravity of the mirror and its appurtenances must be in the axis.

4. THE INDEX.

The index is a most necessary and convenient attachment to a heliostat. The form that I use I have never seen on any instrument. It consists of two holes in a line parallel to the polar axis, through which the sunlight reflected from a corner of the declination mirror is made to pass. These holes are of equal size and are bored each through its own strip of metal. These strips are $4\frac{1}{2}$ inches apart in my heliostat. They are held by a rod parallel to the axis and fastened by adjusting screws to the frame or cradle that carries the first mirror, and project at right angles to this rod. Their position must be adjusted with great care. Probably the best way to do this is to draw another rod temporarily through the holes and adjust this rod parallel to the axis. This latter adjustment may be facilitated by removing the mirror, taking its cradle from the axis of the heliostat, and

placing it upon a longer rod that will serve as an extended axis. When the temporary rod is in satisfactory parallelism, the strips are soldered to their own supporting rod and the adjusting screws tightened. The whole adjustment may be investigated and renewed at any time.

When the instrument is in use, the sunlight, after being reflected from the edge of the first mirror, is made to pass through both holes. Then, if the polar axis is correctly placed, the hour angle and the declination are both automatically cared for. No time piece or almanac is needed, no graduated circles are required in setting up a heliostat that has the index described above, because when the sunlight passes accurately through the holes, it is reflected by the whole mirror exactly along the polar axis. Then, if the second or fixed mirror is turned so as to send the beam in the desired direction, and if the clock behaves well, the heliostat will do all that is expected of it. Graduated hour and declination circles, as I said, are not necessary, although they are very useful, instructive and easily applied.

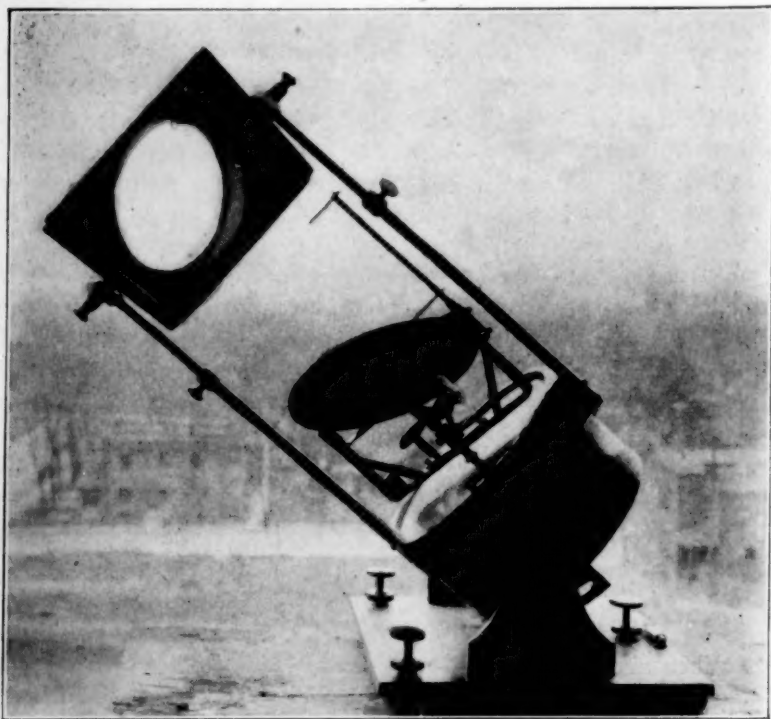
Since the movable mirror may turn about two axes at right angles to each other, the adjustment of the sunlight through the sights is a function of the sun's declination and of its apparent hour angle. The latter adjustment is made rapidly by a milled head on the cradle turning a pinion that meshes into a cog-wheel on the axis. The adjustment in declination is best effected by a slow motion screw working against a spring. The face of the mirror is at an angle of forty-five degrees with the polar axis when the sun is at the equinoxes. At the solstices the mirror is inclined more or less by one-half of twenty-three degrees and a half. In mounting the mirror, therefore, we are sure to catch the sun's rays properly at any season, if we plan to incline it to the polar axis between thirty and sixty degrees.

The second mirror of the heliostat needs no attention. It merely receives and reflects the beam which it catches from the first. It may be mounted on an altogether independent support, but if attached to the heliostat, as mine is, the rods that support it need not be parallel to the polar axis.

5. THE BASE.

When about to be used, the heliostat is instantly levelled and brought into the meridian by means of the following device. A piece of heavy planking has a thin strip nailed to it along one of its longer sides and a thicker one along the other, so that

when resting on these strips on the slanting window sill, its surface is approximately level, and when pushed against the window frame and against one side of the wall, it is sure at all times of observation to occupy the same position firmly. Then using the well-known scheme of the hole, slot and plane, a V-shaped groove is cut into a thick piece of brass and made to receive one of the three feet of the heliostat, while the other two rest upon the heads of bolts screwed into the plank, one with a circular depression and the other perfectly plane. The levelling screws of the heliostat are permanently locked by jam nuts or replaced by non-adjustable feet, and all the levelling and orienting is done by the two bolts set into the plank and by the V-shaped groove. Once this adjustment is completed it is the work of a few moments, to lay the plank upon the window sill and set the heliostat upon it. Then no levelling at all is required. And the heliostat may be carried and set down as quickly in a second or a third prepared place.



THE CREIGHTON COLLEGE HELIOSTAT.

The items mentioned in this paper call for some little patience and many an hour of tedious work, but when one is thereby enabled in a minute or two to set up a heliostat fifty feet away and leave it there without attention for hours, and all that time have a beam of sunlight more steady, more parallel, more brilliant than that of a stereopticon, and absolutely white and noiseless and inexpensive, the reward is well worth the labor devoted to it. An unlimited number and variety of experiments, many of which are beyond the reach of artificial light, are opened up to the interested physicist, but they must remain unknown to all who have not tried this new adjustment, even at the price of the entire reconstruction of their heliostats.

The photograph shows the instrument set up on the east window of the physics lecture-room. The index, described in the text, is plainly visible. The milled head with its cog-wheel adjusts the sunlight on the index in hour angle, and the long screw with its opposing spring to the right of the axis, adjusts it in declination. The V-shaped groove may be discerned under the locked levelling screw at the north-west corner. The bolt head at the south-west corner is used for the afternoon position at a west window. The base is 10 inches square. The upper mirror has its axis set at an angle with the plane of its supporting rods, in order that the shadow of the upper one may not fall on the declination mirror.

LITERARY NOTE.

One of Messrs. Henry Holt and Company's advisers tells them that he believes Dr. William Forbes Cooley, of Columbia University, has bridged the chasm between pure science and philosophy in his forthcoming *Principles of Science*, a college text-book, which appeared December. The book, which is thought will prove a handy introduction to philosophy, utilizes the student's knowledge of logic and leads him to carry on his inquiry according to the intellectual methods of science, with a critical study of which the volume begins.

BIOLOGY IN THE HIGH SCHOOLS.

BY PROF. HERBERT F. ROBERTS,
Kansas State Agricultural College.

A committee of ten, appointed from the Biological Section of the Kansas State Teachers' Association, has had in hand for a year an investigation of the teaching of botany and zoölogy in the Kansas high schools. After due consideration, and extensive correspondence with high school teachers of the biological sciences within the State, and in fifty representative cities of the country in general, a majority of the committee has become convinced that a general course in biology, rather than separate courses in botany and zoölogy as such, should be given in the second year of a four year high school course as at present generally organized.

The reasons for the committee's conclusions are given in the resolutions appended below. The resolutions in question were not adopted by the biological section at the present meeting, but the committee was continued for another year in order to carry on further investigation.

The writer hereof, as chairman of the committee, solicits correspondence on this subject from teachers of the biological sciences in the secondary schools.

It should be stated that this committee is also in favor of the introduction of botany or zoölogy, or both, as electives to be offered later in the course, by high schools that are able and find it expedient to do so. As long as most of our grade teachers who give nature-study work, are themselves largely trained by the high school, it seems desirable for the larger high schools, wherever possible, to offer an opportunity for prospective nature study teachers to get courses in botany and zoölogy.

The committee feels emphatically, however, that for the 95% of the high school graduates who go no further, and who will take but one course in the natural sciences in the high school, that a general course in biology is the one that should be taken. The writer is very well aware that the kind of course that has generally gone under the name of "biology" is not what we want. For example, most of the present text books now offered under the title, consist of a lame course in elementary botany, followed by a reproduction in miniature of a standard course in zoölogy, beginning with Amoeba and Paramoecium and ending with man. These two courses are then bound into one volume often with

an *Anhang* of human "physiology," not forgetting narcotics and stimulants. Now this is not the kind of a course in "biology" our committee is asking for. Nor do we favor the other sort of a "combined" course so-called, in biology, in which the "combination" consists simply in the intercalation of forms, shuffled together like cards in a pack, now a plant and now an animal, today a fern and tomorrow a frog, with no rational connection or evident fundamental theme.

What the majority of our committee favor, is a course that has not yet appeared, but which we believe can and will be developed; a course in which the central guiding idea—the *Leitmotiv*—shall be general physiology, for the teaching of which there shall be chosen from the plant and animal kingdoms, those forms that can best be used to illustrate the performance of the chief physiological functions.

Furthermore we feel that such a course should be organized distinctly with a view to human values; that it should have a definitely useful bearing on the pupils' lives. By this we do not mean that it should teach the things dictated by a shallow sense of the "practical," nor that it should be a "dollar course" in any sense of the word. We feel that it should do for the pupil, however, what the current courses in botany and zoölogy as generally given do not do,—it should directly aim its teaching at the pupil's own life and the life of the race. It should affect by rendering more effective their lives. The present courses aim the pupil at animals and plants. We favor reversing the process and aiming the animals and plants at the pupil. The purpose should be not so much to teach the high school pupil "botany" or "zoölogy" *as such*, but to use animals and plants together to give him some of the general fundamental processes that he ought to know about, as going on in all living things, together with such special biological training as will be of real usefulness to him in his own struggle for existence.

In a word, such a biological course should have real survival value to the pupil and to the race. That the present courses in botany and zoölogy as given in the high schools, are frequently not of the least vital value so far as the lives of the majority of high school pupils are concerned, is the personal opinion of the present writer, and of very many teachers of biology in secondary schools.

One teacher writing from a high school in an important New England university city, says:

"As a teacher of botany to boys preparing to enter —, I should say that the gravest faults seem to be those that are forced on us by the college entrance requirements. This course is presented to High School sophomores. They are expected to grasp the full significance of anatomy, physiology, ecology and classification of plants in four forty-minute periods a week for a year. I do not think they can grasp and retain what they have drilled into them, and I think it is not right to give them so much detail."

Another from an important southern city writes:

"There is, I think, a tendency to pattern the high school course after the college course. A more effective method would be to present a course that would consist largely of the study of external structures, habits and life-histories of plants and animals, and their relation to man."

One teacher writing from a large city in the Middle States, says:

"College biology in high schools is the curse. It is doing more to put biology into ill repute than any other factor."

"I believe that the sciences have been taught in such a way as to discourage pupils from taking them. What we need is teachers trained to teach the sciences so that the layman can understand them. We have a body of teachers who give the same material in the high school that they themselves received in college."

A teacher in one of the most important cities in the Rocky Mountain States, writes from the botanical standpoint:

"The course in botany as now outlined for the high schools of the United States in order to meet college requirements, is an ideal course *for the freshman class of the University*. It is entirely too technical for the average high school pupil. Of course high school pupils can have it drilled into them, and the most of them can pass an examination in it, and will then proceed to forget all about such subjects as alternation of generations, mitosis, evolutionary advancement of the different groups, life-history of gymnosperms and angiosperms in detail, etc. The demand for more practical work in our biological courses is not ill-timed."

A teacher in one of the largest and most prominent university cities in the North Central States writes as follows:

"There is a tendency to make the subjects too technical, both in terminology and in general aim, with the result that the subjects are taught rather from the university point of view, than from the standpoint of a boy or girl who wants some general information which has direct bearing on the facts of every day life."

What purpose do such high school courses as these in botany and zoölogy have then? They "prepare for college." Prepare whom? Less than 5% of the pupils graduating! It plainly appears that in very many places the influence of college and university admission standards has imposed upon high schools a certain stereotyped content of botanical and zoölogical teaching, utterly unsuited to high school pupils, and to the most of them of little or no life value. As a matter of fact, in the State of Kansas, this particular evil does not exist, since the University of Kansas has very broad and liberal admission standards. Often,

however, where the moral compulsion of the university admission standard does not impose this kind of teaching on the victims, it is accomplished with equal effectiveness by means of teachers just emerged from a university atmosphere, who, with a sublime ignorance of life and of children, proceed to transplant their university courses bodily into the atmosphere of the high school.

If any authority be needed for the support of the committee's general contentions, irrespective of the special question of a single course in biology, we refer to the Report adopted July 11th, 1911, by the Secondary Department of the National Education Association, on the Articulation of High School and College.

It may be interesting to remark that the report in question was not received by the committee until after its own report had been presented, so that the concurring views expressed in part by our resolutions have been arrived at quite independently.

Following are the resolutions of our committee, to which the attention of secondary school teachers of biology is requested. Criticism and correspondence is cordially solicited.

Whereas we hold—

1. That the function of education is not so much to convey information, the possession of which, by tradition or custom is deemed desirable as such, but

2. That the purpose of education is primarily to train individuals in such ways as to induce and enable them to make the most and the best of their hereditary equipment for the benefit of society, and hence of themselves, and

3. That the prime essential in education is the training of the power to form independent judgments accurately, in matters affecting the welfare of the race and of the individual;

4. And whereas in the various stages of the educational process, from the kindergarten to the University, different means, materials and methods must be used to this end, having in view the probable length of time that the majority of the pupils will remain in school, and in particular the probable life occupations that most of them will assume in the community;

5. And whereas further, it is an acknowledged fact that on the average but five per cent of the graduates of the high schools are found to proceed with their education by entering the colleges and universities, while the remaining ninety-five per cent pass immediately into the economic life of the community, we therefore hold,

6. That the manifest function and duty of the high school in all its work is to shape its teaching chiefly with reference to the community life, while not neglecting to provide also a proper preparation for those of its pupils who should be encouraged to enter institutions of higher learning.

In accordance with this principle we further hold—

7. That the chief reason for the study of animals and plants in the high school must necessarily lie in the immediate human value, and the service in life, which the knowledge and training thus gained may bring

to the overwhelming majority of high school pupils who can go no further, and we therefore maintain,

8. That the teaching of the biological sciences in the high schools should be governed strictly by the larger needs of the life of the community, and that such teaching should not be shaped primarily in conformity to standards imposed from without. We hold, in other words, that the real problem is, not how much, theoretically speaking, a high school pupil can be made to know of the subject matter of botany and zoölogy, as organized branches of human knowledge, but rather, in what way this organized knowledge can best subserve his needs in the community:

Among these social needs and life uses which such biological training affects, we may mention—

- (1) General bodily health, personal and social hygiene, and sanitation.
- (2) Eugenics and race improvement.
- (3) Economics of the home with reference to sanitation, the nature and kinds of food, and the animal and plant sources from which foods are derived.
- (4) Agriculture in the widest sense, as the ultimate fundamental occupation, determining the food supply of all the people.
- (5) The development of power in the pupil to meet and solve the problems of life.

Finally—

(6) In so far as may be possible at the same time, this biological training should give such a notion of the general nature of the factors conditioning and the problems confronting life, as it is possible for pupils of from twelve to sixteen years of age to grasp.

In accordance with the principles and aims enunciated above, we believe,

First—That the furtherance of these ends by the high school would in general best be brought about by the introduction in the second year of a four-year high school as now generally organized, of a single course dealing largely with the habits, life histories and physiology of plants and animals, including man, refraining from a too detailed study of anatomy and morphology, and endeavoring also to promote and develop, and then to satisfy, a curious interest in the natural history of organisms as the best means of stimulating a further interest later in the deeper problems of life.

Second—That such a general biological course should have a distinctly economic bearing upon the pupils' lives. It should make especial use of the life-histories of our economic plants and animals, and should consider the biological significance of the methods used in their culture. It should, by way of illustration, acquaint the pupil with the economic significance, life-histories, habits and modes of combating and destroying the plant and animal foes of man.

It should bring the pupil of the rural high school into elementary but actual contact with those methods of plant breeding which are calculated to give the race and his own community an increased asset through the possession of strains of plants having superior economic value.

Third—Such a biological course should further teach, through the medium of plant and animal life, the nature, significance and importance of the sex processes, and the possibility of race improvement open to each individual through his progeny.

Fourth—It should teach in a simple way, at the close of the course,

something of organic evolution, and of life and death as the biologist sees and interprets them.

Your committee believes that the furtherance of these principal aims can best be subserved by giving much greater attention to physiology and habit studies, and that a knowledge of the responses and dynamic relations of animals and plants, not only is of greater interest, but of greater importance to the average high school pupil, than an intimate microscopic study of the structure of types arranged to represent a supposedly phylogenetic series.

Fifth—Such a course should develop power in the pupil to deal directly with life in its various relations.

CONCLUSIONS.

Among the chief defects in biological teaching, not only in our own high schools, but, as we find, in high schools generally, are those which arise from following methods and aims the opposite of those for which we contend.

We urge therefore that the high schools should not make the mistake of shaping their teaching chiefly for the benefit of the few who will enter institutions of higher learning.

We further contend strenuously against the false pedagogical doctrine that the teaching of things intrinsically of little value to the life of an individual and therefore uninteresting to him, should be encouraged for the sake of the formal discipline involved in going through the forms of thought required.

We contend that in the vast majority of such cases, the actual forms of thought are not gone through with at all, but that whatever apparent results are obtained, consist for the most part of mere enforced feats of memory that do not affect the judgment or form the character of the pupil, or remain permanently with him as useful or effective knowledge.

We would call attention to some further defects in the present teaching of botany and zoölogy in Kansas high schools.

We find that the average high school teacher, even though well trained professionally, as he should be, often finds it difficult to interpret correctly the aims of the high school.

He frequently tends to make his high school teaching of the biological sciences, a slavish imitation of his university courses. We hold that this is a ridiculous mis-application of knowledge.

The present school text book law, by virtue of the limitation in price which it imposes, prevents the intelligent adoption of superior and desirable biological texts, but limits our schools to the use of the one with the lowest market price. This is a pernicious and absolutely indefensible provision which demands amendment.

Teachers of botany and zoölogy in our high schools are not generally required to have a training equivalent to that required of the prospective teacher of Latin or Mathematics. Teachers are frequently appointed, whose training in the subject amounts to a college Freshman course or less.

In many schools, botany and agriculture are taught by the same person as a single course. The course in plant and animal life recommended herein should be taught as a distinct course by a person who has had proper professional training and should precede the course or courses in agriculture as given in the high school.

As a defect we would call attention to the fact that in the Kansas High Schools, biological teaching means over-whelmingly the teaching of botany. We contend that the study of animal life is of equal importance,

and cannot be substituted for without loss, by the exclusive study of plant life. Since most high schools apparently cannot under present prevailing conditions, afford more than one year of biological science, we believe, as we have already recommended, that a combined year's course in plant and animal life would correct the one-sidedness now evident in our teaching.

We further recommend the extension of plant and animal studies through the grades from the first grade to the high school, with competent supervision to the fifth grade, and with departmental instruction through the remaining grades.

We further recommend that in the smaller towns the teacher of biology in the high school be made supervisor of plant and animal studies in the grades, instead of being assigned to other unrelated subjects in addition to his high school teaching of biology.

The membership of the committee which framed the above resolutions was as follows:—H. F. Roberts, Professor of Botany, Kansas State Agricultural College (Chairman); O. P. Dellinger, Professor of Biology, Kansas State Manual Training Normal School; E. J. Dummond, Principal, Garden City High School; Wyman Greene, Wichita High School; W. E. Ringle, Principal, Cherryvale High School; J. W. Scott, Instructor in Zoology, Kansas State Agricultural College; W. C. Stevens, Professor of Botany, University of Kansas; Edith M. Twiss, Professor of Botany, Washburn College; W. B. Wilson, Professor of Biology, Ottawa University; L. C. Wooster, Professor of Biology, Kansas State Normal School.

Of the above, Mr. Greene was absent and not voting, and Professors Stevens and Twiss non-concurred in respect to the paragraph of the report favoring a single biological course. Otherwise the report was unanimously adopted.

ELK AND BUFFALO IN YELLOWSTONE PARK.

The elk that winter in the Yellowstone National Park now amount to over 30,000 according to the report of the Acting Superintendent of the park just made public by the Department of the Interior. "The problem of handling this large herd of elk to the best advantage," says Lieut. Col. Brett, "has become an important one, and one in which many are interested. The Department of Agriculture has, in the interests of the elk, limited the grazing districts for sheep in the National Forests adjoining the park; the States of Montana and Wyoming have set aside game preserves adjoining the park for the protection of the elk and other game; and the latter State as well as the Federal Government has spent money to feed the elk that winter in Jackson Hole."

"The Buffalo in the park," says the Acting Superintendent, "are in two herds—a wild and a tame one. A special effort was made during the month of July to determine as nearly as possible the exact number of buffalo in the wild herd in the park. Forty-nine animals, including 10 this year's calves, were counted. This is the largest number reported for more than 10 years, and the number of calves indicates that the herd is thriving beyond expectation.

"At the present time there are 143 animals in the tame herd, 58 males, 61 females, and 24 this year's calves, sex undetermined.

"A disease attacked the herd in December, just after the buffalo were taken up from the range where they had been day-herding during the summer, and 22 died before it could be stopped. The Department of Agriculture sent a veterinarian to the park to do what he could, and after examination of specimens from the dead animals sent to that department in Washington the disease was pronounced to be hemorrhagic septicemia, although its symptoms were at first thought to be those of

black-leg. The carcasses were burned and all precautions taken to prevent further spread of the disease. In June a veterinarian was sent out by the Department of Agriculture, who vaccinated all of the adults of the herd with serum prepared and furnished by his department, as a protective measure.

"In addition to the 22 animals that died of disease, 2 bulls and 4 cows have died or had to be killed for various causes during the year. These, however, were of but little loss to the herd, as they were old or decrepit animals and unfit to remain with the herd.

"By constant herding during the summer the herd has become used to being driven, and as a rule is handled with but little trouble on the range. The usual show herd of 15 bulls was brought into the field near Mammoth Hot Springs at the beginning of the tourist season, so they could be seen by travelers, and was returned to the main herd on September 18."

CHARTS ILLUSTRATING THE EFFECTS OF COMMON DEFECTS OF THE EYE.

BY W. M. WINTON,

Agricultural and Mechanical College of Texas.

One of the most puzzling subjects to the beginner in the study of physiology is that of the common optical defects. Even elaborate mechanical devices such as the Kuehne's Eye sometimes fail to clear the subject; and, at times, may even increase the confusion. I find that this is largely due to the fact that the average beginner, either from lack of imagination, or from incorrect previous ideas of the terms used, fails to understand the subjective symptoms associated with the various types of defective eyes. When the subjective effects are clearly understood, the student has very little difficulty in grasping the optical principles involved.

The accompanying charts were developed after much experiment and seem to have been very successful in stimulating the youthful imagination. They were used in my classes in the Oklahoma State Normal school for a number of years, and were widely copied by my students in their own classes. The drawings can be made by any one who can manipulate a ruler and a "T" square. The original charts were made with charcoal on rough drawing paper about 2 ft. x 3 ft. in size. When a second set was made, a year later, it was discovered that a black wax pencil was much better than charcoal.

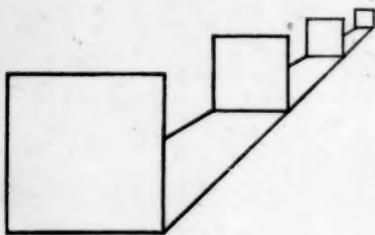


FIG. 1.

The Receding Planes as Seen by Good Eyes.

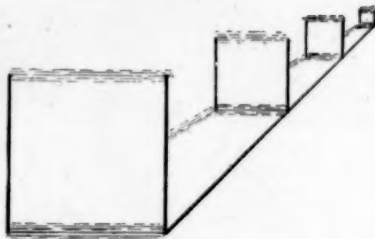


FIG. 2.

The Effect of "Horizontal" Astigmatism. There are Hundreds of Kinds of Astigmatism, but the Effect in Each Case Is to Show Objects Dim in One Plane.

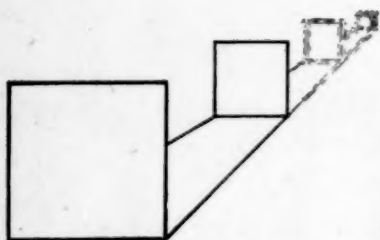


FIG. 3.

As Seen by Near Sighted Eyes.

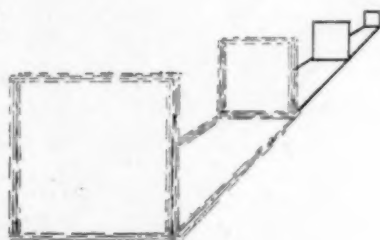


FIG. 4.

As Seen by Far Sighted Eyes.

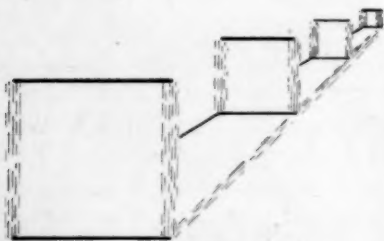


FIG. 5.

The Effect of "Vertical" Astigmatism.

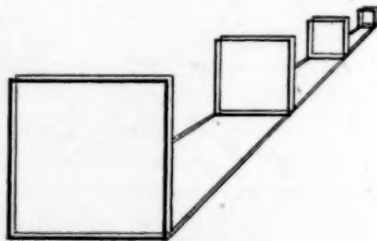


FIG. 6.

The Effect of Strabismus. Strabismus Is Any Displacement of One Eyeball. There Are Many Forms, Including Cross Eye, Cocked Eye, Drooped Eye, Etc.

ARTICLES IN CURRENT PERIODICALS.

American Naturalist for November: "The Mendelian Notation as a Description of Physiological Facts," Professor E. M. East; "A First Study on the Influence of the Starvation of the Ascendants upon the Characteristics of the Descendants. II," Dr. J. Arthur Harris; "Structural Relations in Xenoparasitism," Dr. W. A. Cannon; "Shorter Articles and Discussion: On Tricolor Coat in Dogs and Guinea-pigs," Arend L. Hagedoorn; for December—"The Mendelian Inheritance of Fecundity in the Domestic Fowl," Dr. Raymond Pearle; "Reflections on the Autonomy of Biological Science," Professor Otto Glaser; "The Spawning Habits of the Sea Lamprey, *Petromyzon marinus*," Dr. L. Hussakof; "Shorter Articles and Discussion: A Simple Test of the Goodness of Fit of Mendelian Ratios," Dr. J. Arthur Harris.

Education for December: "Why Teachers Fail; Fundamental Causes and Remedies," Joseph Kahn; "Outlines of Educational Hygiene, Emphasizing Medical Supervision," Louis W. Rapeer; "Training for Social Efficiency; The Relation of Health to Efficiency," Laura H. Wild.

L'Enseignement Mathématique for November: The entire number is given to a report of the Fifth International Congress of Mathematicians, held at Cambridge last August. A list of the publications of the committees appointed in all countries is given with the price of the reports, and the publishers.

Mathematical Gazette for December: "The Teaching of Limits and Convergence to Scholarship Candidates. II," W. P. Milne; "A Case of Three Rotating Lines and the Point 'O,'" F. Glanville Taylor; "Reform of Mathematical Teaching in Germany," E. Allan Price.

National Geographical Magazine for November: "Glimpses of the Russian Empire" (with 51 photographs in color) William Wisner Chapin; "The Land of Promise" (with 7 illustrations and map), A. W. Greely, Major General, U. S. Army; "The Albanians" (with 14 illustrations), Theron J. Damon; "The Rise of Bulgaria" (with 13 illustrations), James D. Bourchier; "The Races and Religions of Macedonia" (with 14 illustrations), Luigi Villari; "Grass Never Grows Where the Turkish Hoof Has Trod" (with 18 illustrations), Edwin Pears; "Two Solutions of the Eastern Problem" (with 7 illustrations and map), James Bryce.

Open Court for December: "An Ancient Egyptian Mechanical Problem; Papyrus Anastasi I" (with diagrams), F. M. Barber; "The New Morality," F. W. Orde Ward; "Early Christian Missions in Japan and Their Influence on Its Art" (illustrated), Oscar Münsterberg.

Photo-Era for December: "At-Home Photography by Flashlight," David J. Cook; "What a Beginner Ought to Know," E. L. C. Morse; "American Congress of Photography," Charles F. Townsend; "Photography in the Service of Painting," W. H. Idzerda.

Physical Review for November: "On Electromagnetic Induction and Relative Motion," S. J. Barnett; "On Electrostatic Screening by Thin Silver Films," Miss Shirley Hyatt; "Notes on the Elastic Peculiarities of Platinum-Iridium Wires," L. P. Sieg; "Analysis of Complex Sound Waves," C. W. Hewlett; "A New Method of Photographing Sound Waves," Arthur L. Foley and Wilmer H. Souder; "Oscillographic Study of the Singing Arc," J. E. Hoyt; for December—"Viscosity and Fluidity. A Summary of Results," Eugene C. Bingham; "Some Remarkable Cases of Resonance," C. V. Raman; "The Potential and Electrostatic Force in the Field of Two Metal Spherical Electrodes," Geo. R. Dean; "An Attempt to Detect Possible Changes in Weight or Momentum Effects on Charging a Condenser," P. G. Agnew and W. C. Bishop; "A General Problem in Gyrostatic Action," J. W. Milnor; "On the Nature of the Volta Effect," Fernando Sanford.

Psychological Clinic for December: "Retardation in Nebraska," William H. Stephenson Morton, Superintendent of Schools, Ashland, Neb.; "The Borderland Between Feeble-mindedness and Insanity," Clara Harrison Town, Director of Department of Clinical Psychology, Lincoln State School and Colony, Lincoln, Ill.

Popular Science Monthly for December: "The Evolution of the Dollar Mark," Florian Cajori; "Practical Forestry Explained," General C. C. Andrews; "Insects as Agents in the Spread of Disease," Charles T. Brues; "The Genesis of Individual and Social Surplus," Alvan A. Tenney; "Rising Prices and the Public," John Bauer; "The Function of the American College," A. K. Rogers; "Reforming the Calendar," Oberlin Smith; "Basil Valentine; A Seventh-Century Hoax," John Maxson Stillman; "The Hindu-Arabic Numerals," Edmund Raymond Turner.

School Review for December: "College Students' Comments on Their Own High-School Training," Edward O. Sisson; "The Reorganization of the Grades and the High School," Edward Van Dyke Robinson; "Educational News and Editorial Comment."

School World for December: "Scholarship Reforms," J. L. Paton; "A New Treatment of Parallels and Transversals," R. Wyke Bayliss; "The Correlation of the Teaching of Mathematics and Geography," B. C. Wallis; "Symposium on Science in Girls' Schools," by seventeen persons.

Unterrichtsblätter für Mathematik und Naturwissenschaften, Nr. 7: "Joseph Peter Treutlein," Dir. H. Cramer; "Material für die biologischen Schülerübungen," Prof. Dr. Oels; A "Zur Dreiecksgeometrie," Realgymnasiallehrer B. Kerst; "Ein allgemeiner und eleganter Beweis der Formel $\sin(\alpha + \beta) = \sin \alpha \cos \beta + \sin \beta \cos \alpha$," Dir. Ernő von Szűcs.

PROGRESS IN EDUCATION IN THE PHILIPPINES.

The Director of Education of the Philippine Islands, who is now visiting in this country, says, in speaking of the Filipinos:

"We are not trying to make good Americans of them, but we are trying to make good Filipinos of them, and we are succeeding. We have established, as generally as possible throughout the archipelago, an educational system which we hope will give the greatest possible number of the islanders the kind of education which will do them the greatest possible good—as islanders."

An enrollment of over half a million children in the public schools, taught and supervised by over nine thousand American and Filipino teachers with very practical courses of study from the primary grades up through the professional colleges of the Philippine University, seems to substantiate the conclusion of the Director of Education.

The Bureau has been devoting itself for several years to formulating and putting into operation a program of industrial instruction which is at once logical in its sequence from grade to grade and in close harmony with the industrial needs of the country. That very remarkable success has been achieved in this direction there is no doubt.

The work being done by the educational authorities in the Philippines is, in many ways, one of the most successful accomplishments of our administration of the Islands. It is a field where young men and women of superior qualifications, excellent character, and good preparation, have the best of opportunities to take a large part in the solution of some of the problems now confronting this country and at the same time gain on experience and training which will be of great value.

The government employs men as Supervisors, teachers of English, Mathematics, Science, Manual Training and Agriculture, and women for Home Economics.

The United States Civil Service Commission announces an examination for the Thanksgiving Recess, November 29-30, in various cities of the country for the purpose of securing eligibles to be appointed in the spring of 1913 for work beginning with the opening of the next school year.

PROBLEM DEPARTMENT.

By E. L. BROWN,

Principal North Side High School, Denver, Colo.

Readers of this magazine are invited to send solutions of the problems in which they are interested. Problems and solutions will be duly credited to their authors. Address all communications to E. L. Brown, 3435 Alcott Street, Denver, Colo.

Algebra.

313. Proposed by Elmer Schuyler, Brooklyn, N. Y.

$$\begin{array}{rcl} \text{Solve:} & x^3 + y^3 - z^3 - u^3 = 133 & (1) \\ & x^2 + y^2 - z^2 - u^2 = 15 & (2) \\ & x + y - z - u = 1 & (3) \\ & xy = zu & (4) \end{array}$$

Solution by Walter C. Eells, Tacoma, Wash., and Otto J. Ramler, Buffalo, N. Y.

$$\begin{array}{rcl} \text{From (2) and (4)} & (x+y)^2 - (z+u)^2 = 15 & (5) \\ \text{From (3) and (5)} & x+y+z+u = 15 & (6) \\ \text{From (3) and (6)} & x+y = 8, \quad z+u = 7 & (7, 8) \\ \text{From (7, 8)} & (x+y)^3 - (z+u)^3 = 169 & (9) \\ \text{From (1, 9)} & 3xy(x+y) - 3zu(z+u) = 36 & (10) \\ \text{From (7, 8, 10)} & 8xy - 7zu = 12 & (11) \\ \text{From (4, 11)} & xy = zu = 12 & (12) \\ \text{From (7, 8, 12)} & x = 6 \text{ or } 2, \quad y = 2 \text{ or } 6, \quad z = 4 \text{ or } 3, \quad u = 3 \text{ or } 4. \end{array}$$

Since x and y are involved symmetrically in the given system of equations, as also are z and u , we have the four sets of values:

$$(x, y, z, u) = (2, 6, 3, 4) (2, 6, 4, 3) (6, 2, 3, 4) (6, 2, 4, 3).$$

314. Proposed by H. E. Trefethen, Waterville, Me.

A piece of land in the form of a triangle ABC increases in value from the vertex C toward the base in proportion to the n th power of the distance from a line through C parallel to AB. Divide it by lines parallel to the base among m men so that they each have shares of equal value.

Solution by H. H. Seidell, St. Louis, Mo., and the proposer.

Let a be the altitude of the given triangle, A its area; x the altitude, X the area, of a triangle cut from the given triangle by a parallel to the base. Then

$$A : X = a^2 : x^2 \quad (1)$$

V = the average value of all the units of area in A , p = the distance from C at which this average value per unit obtains; v = the average value of all the units of area in X , q = the distance from C at which a unit area has this average value. Then

$$V : v = p^2 : q^2 = a^2 : x^2. \quad (2)$$

For p and q , a and x are homologous lines in similar triangles, and $p : q = a : x$. Now multiply (1) by (2) and we get

$$VA : vX = a^{2+2} : x^{2+2}.$$

Let x_1, x_2, \dots, x_{m-1} be the distances from C of the dividing lines taken in order from the base. Put $VA : vX_1 = m : m-1$, and $m : m-1 = a^{2+2} : x_1^{2+2}$. Hence

$$x_1 = a \left(\frac{m-1}{m} \right)^{\frac{1}{2+2}}, \quad x_2 = a \left(\frac{m-2}{m} \right)^{\frac{1}{2+2}}, \quad \dots, \quad x_{m-1} = a \left(\frac{1}{m} \right)^{\frac{1}{2+2}}.$$

Geometry.

315. *Selected.*

Construct a triangle, given its pedal triangle.

I. *Solution by A. H. Hughey, El Paso, Texas, and Levi S. Shively, Mount Morris, Ill.*

Let ABC be the given pedal triangle. Draw the bisectors of the exterior angles of ABC. These determine the triangle XYZ which is the required triangle. Suppose XY, YZ, ZX bisect the exterior angles at C, A and B, respectively. Then since the bisectors of the exterior and interior angles of a triangle meet four times by threes, the bisectors of the interior angles A, B, C are AX, BY and CZ, respectively. Also AX is perpendicular to YZ, etc. Thus it is evident that the pedal triangle of XYZ is ABC.

II. *Solution by J. G. Gwartney, Mountain View, Cal., and H. H. Seidell, St. Louis, Mo.*

Let XYZ be the required triangle. ABC the given pedal triangle, having XA, YB, CZ perpendicular to YZ, XZ, XY, respectively.

XY is the diameter of a circle passing through ABXY. Hence the mid-point of XY lies on the perpendicular bisector of the chord AB.

Also the circle circumscribed about the triangle ABC passes through the mid-point of the side XY.

Hence the mid-point of the side XY is determined, and similarly for the other sides.

The construction is then obvious.

316. *F. Eugene Seymour, Trenton, N. J.*

Through a point within a given angle to draw a line which will form with the given sides of the angle a triangle of minimum area.

I. *Solution by T. M. Blakslee, Ames, Iowa, and Levi S. Shively, Mount Morris, Ill.*

Let P be the point within the given angle ABC. Through P draw a line parallel to BC meeting AB in Q. On BA lay off BR = 2BQ. Then the line determined by points R and P is the line which forms with BA and BC the triangle of minimum area.

Proof: Let RP meet BC in S. Draw through P any other line MN (BM > BR). Since angle MRP > angle ABC a line through R parallel to BC will fall within angle MRP. Let this line meet MP at X. Then obviously, triangle RPX = triangle SPN. Therefore triangle SPN < triangle MRP and triangle RBS < triangle MBN.

Similarly for the case in which BM < BR.

II. *Solution by the proposer.*

Let BAC be the given angle and P the given point. Required through P to draw a line DE so that triangle EAD shall have a minimum area. D lies on line AC and E on line AB. Assume DE the line, drop perpendicular from D and P to AB and draw a line through P || to AC. Call the \perp from D, y and the \perp P, h and call the part of AB cut off from A by the ||, K; call AE, x. $\frac{1}{2}xy$ is to be a minimum.

By similar triangles $\frac{y}{h} = \frac{x}{x-K}$ or $y = \frac{h \cdot x}{x-K}$

$\therefore \frac{1}{2} \frac{x^2 \cdot h}{x-K}$ is to be a minimum or $\therefore \frac{h}{2}$ is constant, $\frac{x^2}{x-K}$ is to be a minimum.

Let $x = vK$, then $\frac{v^2 K^2}{vK-K}$ or $\frac{v^2 K}{v-1}$ is to be a minimum.

Or since K is a constant, $\frac{v^2}{v-1}$ is to be a minimum.

$$\frac{v^2}{v^2-1} = \frac{1}{\frac{1}{v} - \frac{1}{v^2}} = \frac{1}{\frac{1}{v} \left(1 - \frac{1}{v}\right)}.$$

This will be a minimum when $\frac{1}{v} \left(1 - \frac{1}{v}\right)$ is a max. Since the two factors $\frac{1}{v}$ and $1 - \frac{1}{v}$ have a constant sum their product is greatest when $\frac{1}{v} = 1 - \frac{1}{v}$ or when $v = 2$.

∴ For a maximum area let $x = 2K$; that is, have the line bisected by the given point.

317. *Proposed by Nelson L. Roray, Metuchen, N. J.*

Given two circles of radii 2 and 9 respectively and the sect 14 between their centers; also the common external tangents. If the figure is made to rotate about 14 as an axis find the volume generated by the entire figure and the area generated by the two tangents and the two arcs not between the two centers.

Solution by Julia M. Bligh, Batavia, N. Y., W. W. Gorsline, Peoria, Ill., and the proposer.

Let O be center of small, and O' center of large circle. Let AC and BD be the common external tangents, the points A and B being on circle O. Let tangent AC lie above, and tangent BD lie below line OO'. Let OO' intersect AB in H and CD in E. From A draw a line parallel to OO' intersecting CO' in F.

By means of the properties of the 30° right triangle it is easily shown that the altitude of the frustum is $2\frac{1}{2}$ and of the segments $2\frac{7}{8}$ and 1. Next is, $HE = 2\frac{1}{2}$, $EO' + R = 2\frac{7}{8}$, and $HO = 1$. Also, $AH = \sqrt{3}$, $CE = \frac{9}{2}\sqrt{3}$, $AC = 7\sqrt{3}$.

$$\text{Vol. Frustum ACBD} = \frac{1}{3} \cdot 2\frac{1}{2}\pi \left(24\frac{3}{4} + 3 + 2\frac{7}{8}\right) = 216\frac{3}{8}\pi.$$

$$\text{Vol. Segment AB} = \frac{1}{2}\pi r^2 h + \frac{1}{6}\pi h^3 = \frac{\pi}{2} \cdot 3 \cdot 1 + \frac{\pi}{6} = 5\frac{1}{6}\pi.$$

$$\text{Vol. of Major Segment CO'D} = \frac{\pi}{2} \cdot 24\frac{3}{4} \cdot 2\frac{7}{8} + \frac{\pi}{6} \cdot (2\frac{7}{8})^3 = 6561\frac{1}{8}\pi.$$

$$\therefore \text{Total volume} = 1092.166\pi.$$

$$\text{Area of minor zone AB} = 2\pi rh = 4\pi.$$

$$\text{Area of major zone CD} = 18 \cdot 2\frac{7}{8}\pi = 243\pi.$$

$$\text{Lateral area frustum} = 231\frac{1}{2}\pi.$$

$$\therefore \text{Total area} = 362.5\pi.$$

Credit for Solutions Received.

308. A. H. Hughey, F. Eugene Seymour. (2)
 309. Katherine M. Stewart, F. Eugene Seymour. (2)
 311. H. E. Trefethen. (1)
 312. A. H. Hughey, H. C. McMillin. (2)
 313. Vernon S. Ames, A. Babbitt, T. M. Blakslee, Julia M. Bligh, E. M. Dow, Walter C. Eells, John M. Gallagher, J. G. Gwartzney, A. M. Harding, L. L. Harding, A. H. Hughey, Adriana M. Liepsner, A. L. McCarty, C. A. Perrigo, Otto J. Ramler, W. J. Risley, Nelson L. Roray, Elmer Schuyler, H. H. Seidell, F. Eugene Seymour, Levi S. Shively, Katherine M. Stewart, H. E. Trefethen, G. A. Van Derhule. (24)

314. H. H. Seidell, H. E. Trefethen. (2)
315. A. Babbitt, Julia M. Bligh, J. G. Gwartney, A. M. Harding, A. H. Hughey, H. C. McMillin, Nelson L. Roray, Elmer Schuyler, H. H. Seidell, Levi S. Shively, C. A. Smith, H. E. Trefethen. (12)
316. Vernon S. Ames, Frank Baconi, T. M. Blakslee, J. G. Gwartney, John A. Hodge, A. H. Hughey, Mae Martinek, Nelson L. Roray, Elmer Schuyler, H. H. Seidell, F. Eugene Seymour, Levi S. Shively, Beatrice Smith, Hartley Speck, H. E. Trefethen. (15)
317. Vernon S. Ames, Julia M. Bligh, E. M. Dow, W. W. Gorsline, A. H. Hughey, Nelson L. Roray, H. H. Seidell, F. Eugene Seymour, Arthur Dodd Snyder. (9)

Total number of solutions, 69.

PROBLEMS FOR SOLUTION.

Algebra.

328. *Proposed by A. Babbitt, State College, Pa.*

Solve:
$$\frac{b(x+y)}{x+y+axy} + \frac{c(z+x)}{z+x+bzx} = a. \quad (1)$$

$$\frac{c(y+z)}{y+z+ayz} + \frac{a(x+y)}{x+y+axy} = b. \quad (2)$$

$$\frac{a(z+x)}{z+x+bzx} + \frac{b(y+z)}{y+z+ayz} = c. \quad (3)$$

329. *Proposed by H. E. Trefethen, Waterville, Maine.*

Find the condition that $x^3-3px+2q$ may be divisible by $(x-c)^2$.

Geometry.

330. *Selected.*

The sides of a triangle are respectively x^2+x+1 , $2x+1$, and x^2-1 . Find the angle opposite the side x^2+x+1 .

331. *Proposed by E. M. Dow, Brighton, Mass.*

In the quadrilateral ABEF the angles B and E are right and the diagonals BF and EA equal 60 and 40 respectively. The distance from D, the point of intersection of the diagonals, to BE is 15. Find length of BE.

332. *Proposed by Elmer Schuyler, Brooklyn, N. Y.*

A room 20 feet by 15 feet, rectangular in shape, has a strip of carpet 2 feet wide placed diagonally so that each of the four corners touch one of the sides of the room. If the carpet is also rectangular, what is its length.

Trigonometry.

333. *Proposed by Nelson L. Roray, Metuchen, N. J.*

If $a^2+b^2+c^2 = 2c^2(a^2+b^2)$, find value of angle C. (Hall & Knight's *Elementary Trigonometry*.)

EDUCATION NOTES.

Twenty-one states in the Union have abolished the common drinking cup in schools.

More than four-fifths of the elementary school-teachers in Prussia are men.

A chair in social hygiene has been established in the University at Munich, Germany.

Two-thirds of the high schools in the United States now have complete four-year courses.

A two years' course in forestry has been instituted at the University of Wisconsin to meet the demand for trained forest rangers.

More than a thousand school teachers in the Netherlands are banded together in an association for temperance work among their pupils.

New Jersey is the first state where the legislature has provided for state wide special training for all subnormal children, retarded as well as defective.

A compulsory school-attendance law for Alaska is urged by Dr. P. P. Claxton, United States Commissioner of Education, who has charge of the schools for natives in the Territory.

2,190 women attended the University of Paris during the past year. 99 studied law, 570 medicine, 248 science, 32 pharmacy, and the remainder were in the course in letters.

An international congress for physical education will be held in Paris, March 17-20, 1913, under the auspices of the Faculty of Medicine. It is expected that the United States will be represented.

At a conference of Swedish teachers recently it was emphasized that instruction in domestic science in the schools must deal principally with the substantial things, instead of the "caramel and tart" kind.

The common roller towel is specifically prohibited in the schools of Indiana and Kansas. The regulations in Kansas provide that "each pupil must have an individual towel, or sanitary paper towels shall be furnished."

The school farm movement in Wake County, North Carolina, which has attracted wide attention, is described by County Superintendent Judd in an illustrated bulletin just issued by the United States Bureau of Education.

Of 82,224 school children recently examined by medical inspectors in a large city-school system only 28,721 were free from physical defect; the remaining 53,503 were found physically defective in one or more particulars.

At the Ghent world's exposition in 1913 there will be a number of international congresses, including one of teachers of domestic science and one of women engaged in farming, the latter in connection with a general congress of agriculturalists.

The woman's law class at New York University is probably unique in that it is not intended to prepare women for the practice of law, but to give them sufficient legal knowledge to conduct the administration of trust estates and other forms of business.

Instruction in elementary mining is recommended by the British Board of Education for schools in mining districts. It is suggested that such instruction can be most effectively given, not in separate and detached lessons, but in connection with the regular school subjects.

In urging the need of vocational training, the Indiana commission on industrial and agricultural education estimates that there are

fully 25,000 boys and girls in that State between the ages of 14 and 16 who have not secured adequate preparation for life work in the schools and are now working at jobs which hold no promise of future competence or advancement.

Ancient farm-houses have been gathered from all parts of Denmark and placed in the grounds of the famous Danish National Museum at Lyngby, with a view to educating the people in their national history. There are galleries filled with old furniture, antique coaches, hearses that belonged to different guilds, with their funeral trappings, and other interesting relics of the past.

Holland affords a good example of public-school progress in the important matter of attendance. In 1900 about 3 in every hundred children did not receive instruction; in 1904 the number had gone down to 2 in every thousand; in 1908 it was 1 to a thousand; and more recently the inspector at Nijmegen was able to announce that there were no children of 13 or 14 years who could not read and write.

The "House of Science" just founded by private benefaction at Tomsk, Siberia, aims to be a popular Siberian university, where free instruction will be given in elementary and advanced subjects. Special evening classes will be held; a library and a museum of practical information will form part of the equipment; and instruction in sanitation and hygiene will have a leading place in the program.

A unique feature of the "Deutsches Haus" of Columbia University is the library, which is unlike any other in that it confines itself to current German literature since 1871. Director Tombo is making the library of the "Haus" essentially "a repository of material of immediate interest," and the result is a collection of books, articles, newspaper clippings and other fugitive material that is not available at any other library or university.

There is a high school over a store at Norris, Missouri. Four families who wanted their children to have a high-school education without going to town for it established such a school over the village store. Nineteen pupils, 5 girls and 14 boys, attended this school last year. The course of study is that of standard Missouri high schools, and the work is fully approved by the State authorities. Other country high schools of the same kind are planned.

The University of Tennessee has just instituted extension courses in geology especially designed for men engaged in the mining and quarry industries. The courses consist of a short session (six weeks) and correspondence work. The subjects of instruction will be: Physics, chemistry, mathematics, geology, mining and metallurgy, and mechanical engineering. The courses are described as especially adapted to meet the need of the man "on the firing line."

Nearly two thousand titles of books and articles on children appear in the "Bibliography of Child Study, 1910-11," compiled by the library of Clark University and just issued for free distribution by the United States Bureau of Education. Such topics of current interest as the Boy Scouts, Binet tests, exceptional children, crime among minors, infant mortality, eugenics, open-air schools, medical inspection, sex education, and vocational training are included in the titles listed.

Soldiers at Fort McPherson, Georgia, will have a school of practical business, if the reported plans of General Evans, in command of the department of the Gulf, are carried into effect. Among the subjects of instruction will be: Intelligent reading, simple arithmetic.

tic, single-entry bookkeeping, legible writing, stenography, automobile and explosive gas engineering, and telegraphy. The idea is to furnish the enlisted man with schooling that will enable him to earn a good living at the expiration of his enlistment. The school is part of a plan to make the army more attractive to young men.

The South African Union has just awarded five government scholarships in agriculture for study abroad. The holders of these scholarships will receive \$750 per year during the three or four years for which provision is made. The successful applicants were obliged to pledge themselves to enter the service of the South African Union after completing their studies, and to remain in the service for at least three years at a salary not less than \$1,500 per annum. Only sons of parents permanently domiciled in South Africa were eligible for the scholarships.

Boys appear to be slightly healthier than girls in Japan, but the girls have better eyesight. According to official reports covering medical inspection of nearly 2,000,000 children in the public elementary schools, 47.7 per cent of the boys had strong constitutions, 47.4 per cent medium, and 4.9 per cent weak; of the girls, 42.7 per cent had strong constitutions, 51.2 per cent medium, and 6.1 per cent weak. Another test was on strength of the spinal column. 95.1 per cent of the boys had a perfect spinal column and 4.9 per cent defective; 94.2 per cent of the girls were perfect in this respect and 5.9 per cent defective. In eyesight, on the contrary, only 86.9 per cent of the boys were normal, as compared with 90.3 per cent of the girls.

PRICE OF GOVERNMENT MAPS INCREASES.

After January 1st the standard topographic maps of the United States Geological Survey will be sold at 10 cents a copy or 6 cents wholesale, an order amounting to \$3 or more entitling the purchaser to the reduced rate. These maps have heretofore been sold by the Director of the Geological Survey, under authority of Congress, at 5 cents retail and 3 cents wholesale, but for some time it has been recognized that this price has been too low. The constantly increasing refinement in the field work of the topographic surveys, the immense amount of detailed information which is put upon the maps, requiring the most expert and tedious drafting and copper-plate engraving, the great care necessary in insuring the exact register for the three or four color lithographic printings, and the largely increased cost of labor and paper have made the increase in charge not only justifiable but necessary. As a matter of fact, 10 or 6 cents for one of the standard 15-minute topographic sheets of the Geological Survey, which is in effect an almost exact reproduction of about 230 square miles of territory, is a merely nominal price. No comparable maps are issued by any private map-printing house, but if there were they would be sold at \$1 to \$3 apiece. The field surveying alone of some areas covered by a single map costs more than \$5,000, and even \$7,000 in very difficult country, while there are few maps which represent an expenditure for field work of less than \$3,000.

All the maps are printed in three colors and some in four colors. The water features, including seas, lakes, ponds, streams, canals, swamps, etc., are shown in blue. The relief—mountains, hills, vales, cliffs, and slopes—is shown by means of brown contour lines, which graphically portray the shapes of the plains, hills, and mountains

and also show the elevation of every part of the area. The works of man are shown in black, in which color all lettering also is printed. Boundaries, such as state, county, city, land-grant, and reservation lines, are shown by broken lines of different kinds. Principal and inferior roads are shown by other kinds of lines. Houses are indicated by small black squares which in the densely built portions of cities and towns merge into blocks. Other cultural features are represented by conventional signs which are easily understood. Many of the maps show also forested areas, which are indicated in green.

The Director of the Survey at Washington will be glad to furnish an index map, covering any area desired, which shows the particular quadrangles, as they are called, which have been surveyed and the corresponding maps issued for sale. This index-map circular also contains a list of special maps of the United States, of states, and of national parks, mining camps, etc., with the prices, and a list of available geologic reports on any part of the area shown.

SALARIES OF CITY SCHOOL SUPERINTENDENTS.

The highest salaries for city school superintendents in the United States are paid by New York, Chicago, and Boston. New York recently increased her superintendent's salary from \$10,000 to \$12,000; Chicago pays her woman executive \$10,000; and Boston pays the same amount to her new administrator. Pittsburgh pays the head of her system \$9,000; St. Louis pays \$8,000; and Philadelphia, Seattle, and Buffalo each \$7,500.

Eight cities are reported in the \$6,000 group as regards salaries to school superintendents. These range from large cities like Detroit and Milwaukee (the former with 465,766 inhabitants and the latter with 373,857 by the 1910 census), down to Montclair, N. J., population 21,550, and Gary, Indiana, with 16,802. Other cities in the \$6,000 class are: Los Angeles; Jersey City; Cleveland; and Newark, N. J.

In the South the best-paid superintendents are at Birmingham, Alabama, and New Orleans, both of whom receive \$5,000. The former has served since 1883. The superintendent at Washington, D. C., also receives \$5,000, as do the heads of school systems at Des Moines, Iowa; Pasadena, Cal.; Louisville, Ky.; Baltimore, Md.; Newton, Mass.; Bayonne, N. J.; Rochester, N. Y.; Yonkers, N. Y.; Dayton, Ohio; Toledo, Ohio; Denver, Colo.; and Scranton, Pa. Minneapolis reports a salary of \$5,500.

These figures are from the "Educational Directory" for the current year just issued for free distribution by the United States Bureau of Education. The directory contains, besides a list of school superintendents in cities and towns of 4,000 population and over, with salaries and term of office, the following lists: Chief State school officers; State boards of education and library boards; county superintendents; professors of pedagogy and heads of departments of education in universities and colleges; university and college presidents; principals of normal schools, public and private; educational associations; and summer-school directors, with probable date of the 1913 sessions of the summer schools.

TWELFTH ANNUAL MEETING OF THE CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS.

The twelfth annual meeting of the Central Association of Science and Mathematics Teachers was held at Northwestern University, Evanston, Ill., November 29 and 30, 1912.

The timely nature and the strength of the addresses given, both in the general sessions and in the meetings of the five sections, and the pronounced enthusiasm aroused thereby mark this as one of the most fruitful meetings ever held by the Association; while the large increase in membership during the past year, as shown by the report of the Secretary-Treasurer, together with the widening geographical distribution of this membership, gives gratifying assurance of the increasing influence of the Association.

The first general session was held Friday morning, November 29th, in the auditorium of Fisk Hall, and was presided over by President Herbert E. Cobb. The address of welcome was delivered by President Abram W. Harris. The response in behalf of the Association was made by F. E. Goodell, North Division Manual High School, Des Moines, Iowa. The main address at this session was delivered by Professor William C. Bagley of the University of Illinois, on "Vocational Guidance by the Science Teacher." This address was extremely suggestive and helpful and will have great influence in directing the thought of teachers in a comparatively new field of school activity.

The Biology, Physics, Chemistry, Earth Science, and Mathematics Sections held their meetings Friday afternoon and many addresses of moment and several important reports were made at these sessions. Full accounts of these will be found in the minutes of the different sections.

The annual dinner was held at 5:45 in the dining room of Willard Hall. After the dinner many of the members of the Association accepted the invitation thoughtfully extended by the University, to visit Dearborn Astronomical Observatory, and spent a very interesting and profitable hour in the inspection of its equipment and in the use of the large equatorial refracting telescope. The address of the evening was delivered by Carroll G. Pearce, Superintendent of Schools, Milwaukee, Wis., on "High School Science and Mathematics as Related to the Community." Superintendent Pearce led all his hearers to appreciate keenly the great influence for civic betterment and enlightenment that may be exercised in the course of their regular work by the teachers of science and of mathematics in our secondary schools.

The annual business meeting of the Association was held Saturday morning, followed by meetings of each of the Sections. The Physics and the Chemistry Sections adjourned after their business meetings in order to give their members an opportunity to attend the meeting of the American Physical Society then in session in Fayerweather Science Hall.

The proceedings, containing all addresses delivered at the general and at the section meetings, or abstracts thereof, and all reports presented, will be published at an early date and placed in the hands of each member of the Association.

At the business meeting Saturday morning, Dr. C. R. Mann, representative of this Association in the American Federation of Teachers of the Mathematical and the Natural Sciences, reported on the work accomplished by the Federation during the past year. The

report, which dealt with the reorganization of the Federation, with its work in preparing and distributing the report of the "Committee on Geometry, and with the investigation it is now making for the purpose of improving methods and apparatus used in the teaching of physics, produced a very favorable opinion of the great and growing usefulness of the Federation.

The auditing committee reported that they had found the accounts of the Secretary-Treasurer correct.

The Secretary's and Treasurer's annual reports were then read and adopted.

James F. Millis, chairman of the committee appointed at the last annual meeting to prepare amendments to the constitution of the Association, presented the report of the committee. The amendments adopted increase the number of general officers, define their duties, and terms of service, and designate the membership of the Executive Committee of the Association. The revised constitution will be printed in the volume of Proceedings for 1912.

A resolution was passed providing that the total expenditure arising from the publication of the annual volume of Proceedings should be limited to one hundred and eighty-five dollars.

The Executive Committee was instructed by resolution to determine the sentiment of the members of the Association concerning the desirability of a change of the date for the annual meeting, and to report the result of the inquiry at the next annual meeting.

A motion presented by James H. Smith was adopted, instructing the chairman to appoint a committee of five to consider the entire subject of a complete course in science for the four years of the high school, to formulate such a course, and to report to the Association at a general session next year. This committee was empowered to increase its own membership, and a sum not to exceed seventy-five dollars was appropriated for its use.

The members of this committee are: Otis W. Caldwell, University of Chicago, Chairman; James H. Smith, Austin High School, Chicago; C. E. Spicer, Joliet Township High School, Joliet, Ill.; Albert W. Evans, Newberry School, Chicago; Wm. M. Butler, Yeatman High School, Saint Louis, Mo.

A strong sentiment in favor of holding the next annual meeting at Des Moines, Iowa, was evident in the meeting, but the final decision in the matter was left, as usual, to the Executive Committee.

The following resolutions were adopted:

Resolved, That the Association tender a vote of thanks to the Trustees and the Faculty of Northwestern University for the hospitality accorded in the use of buildings, for the facilities afforded for holding the several meetings, and for the special courtesies extended in opening the observatory to the members of the Association, and in giving the exhibition by the crew of the University Life Saving Station. Further

Resolved, That the Association express its thanks to Professor Mansfield and the local committee for their thoughtful care in making complete and detailed provision for the needs of the meeting.

Resolved, That the Association express its appreciation of the timely, instructive and interesting addresses given at the general sessions by President Abram W. Harris, Prof. W. C. Bagley, and Superintendent Carroll G. Pearse.

Resolved, That the Association express its hearty appreciation of the able and untiring efforts of the retiring President, Prof. H. E.

Cobb, and of the retiring Secretary-Treasurer, C. E. Spicer, in advancing the growth and the usefulness of the Association and in keeping its interests before the teachers of the country.

Resolved, That the Association encourage the work begun in various sections in devising effective methods for testing the efficiency of the teaching of science and mathematics.

Resolved, That this Association cordially approves the efforts being made to vitalize the instruction in science and in mathematics by making the work more concrete through the study of problems arising in every day experience and practical processes which are closely allied to vocational work.

Resolved, That the problem of vocational guidance, and enlightenment by the science teacher, discussed at this meeting by Dr. Bagley, is timely and significant and should be given careful consideration by the Association.

Resolved, That, in view of the rapid evolution of educational thought within the last few years regarding courses of study, and in view of the development of many new phases in the teaching of science, that the topic of a complete high school course in science extending through the four years, be given a prominent place in the general program of the meeting next year.

Resolved, That this Association deprecates the division of the management of any school system into two parts as suggested in the proposed bill for vocational education to be presented this winter before the legislature of Illinois, since such division would tend to degrade schools in the public mind and to create class distinctions incompatible with democracy.

WILLIS E. TOWER,
JAMES F. MILLIS,
D. A. LEHMAN, *Committee.*

The following officers were elected for the ensuing year: President, James F. Millis, Francis W. Parker School, Chicago, Ill.; Vice-President, Frank E. Goodell, Manual High School, Des Moines, Iowa; Secretary, W. L. Eikenberry, University High School, Chicago, Ill.; Assistant Secretary, Ira S. Condit, Iowa Teachers College, Cedar Falls, Iowa; Treasurer, C. E. Spicer, Joliet Township High School, Joliet, Ill.; Assistant Treasurer, Charles Ammermann, McKinley Manual Training High School, St. Louis, Missouri.

Membership Report For the Year Ending November 27, 1912.

Paid up membership, Nov. 29, 1911	486
Honorary membership, Nov. 29, 1911	7
Total membership, Nov. 29, 1911	493
Delinquent, but left on list as per constitution	103
Total names on list Nov. 29, 1911	596
New names added during year	115
	711
Resigned during the year	39
Deceased, or dropped for delinquency	39
	78
Total names on list, Nov. 27, 1912	633

Delinquent but left on list as per constitution	67
Honorary membership, Nov. 27, 1912	7
Paid up membership, Nov. 27, 1912	559
Net increase of membership for the year	73

C. E. SPICER, *Secretary*.**Treasurer's Report For the Year Ending Nov. 27, 1912.****Receipts.**

Balance shown by last report	\$ 331.34
117 dinner tickets at 60c	70.20
2 Copies Correlation Report at 25c50
1 Copy 1910 and 1 copy 1911 Proceedings at 50c	1.00
Advertisements in 1911 program	149.00
Advertisements in 1912 program	20.00
Dues of 415 members at \$2.50	1,037.50
Dues of 33 members from local centres at \$2.00	66.00
Dues of 17 members from local centres at \$1.00	17.00
Dues of 74 members from local centres at 50c	37.00
Total receipts	\$1,729.54

Expenditures.

Subscriptions to School Science and Mathematics	\$ 687.50
117 dinners at 1911 meeting at 50c	58.50
Printing and distributing 3,000 programs for 1911 meeting..	290.89
Expenses of Section meetings for 1911	3.50
Badges for 1911 meeting	7.50
Expenses for check room, printing dinner tickets, etc., at 1911 meeting	7.70
Expenses of Committees of Sections	23.66
Stenographer for 1911 meeting	30.00
Reprints of Tower's report and of Judd's paper	8.00
Printing and distributing Proceedings for 1911	241.97
Dues to the National Federation of Teachers of the Mathematical and Natural Sciences at 10c per member....	48.60
Rebates to local centres of dues of members	6.00
Premium on Treasurer's bond for \$1,000	2.50
Expenses for transferring Sec'y-Treasurer's supplies	2.32
Postage in office of Sec'y-Treasurer	30.10
Printing letter heads, envelopes, "circular of information," circular letters, application blanks, etc.	46.90
Total expenditures	\$1,495.64
Balance cash on hand	233.90

\$1,729.54

C. E. SPICER, *Treasurer*.**MINUTES OF THE BIOLOGY SECTION.**

This section was called to order by the Chairman, Mr. F. W. Werner, at 1:30 o'clock Friday afternoon. In the absence of the secretary, Mr. Locke, the chairman appointed Miss Ada L. Weckel to act as secretary. The section unanimously accepted this appointment.

The meeting was then opened with the appointing of the nominat-

ing committee, consisting of Faith McAuley, Celestine Rice, and Clarence Holtzman.

The first paper of the afternoon was presented by Prof. William A. Locy, Professor of Zoölogy at Northwestern University, on "The Widening Horizon of Zoölogy." He called attention to the fact that much of Zoölogy as it is now taught is fragmentary. Teachers should avoid giving pupils unrelated fragments of knowledge. Zoölogy is synthetic as well as analytical.

To get a good back-ground for the study of Zoölogy, Prof. Locy suggested the picking out of the great zoölogical events of the nineteenth century:

1. Development of protoplasm and the realization of the part it plays.
2. Development of cell theory and its broad application.
3. Establishment of the doctrine of organic evolution.
4. Rise and development of science of bacteriology.

A study of the contributions to science made by notable men of the century might also be made. The ten men selected were Cuvier, Lamarck, Von Baer, Müller, Schwann, Schultze, Darwin, Pasteur, Mendel and Huxley.

The importance of present day tendencies in zoölogy should not be underestimated.

For the full appreciation of the synthetic method in zoölogy the reading of such books as the following was suggested: "Study of Animal Life," Thomson; "Life and Letters," Huxley; "Life and Letters," Darwin; "Lamarck," Packard; "Darwin and After Darwin," Romanes; "Mendel and Mendelism," Bateson.

In the discussion of this paper which followed, it was suggested that Prof. Locy's excellent book, "Biology and Its Makers," be added to the above list of works.

The next paper was presented by Dr. William Crocker, Assistant Professor of Plant Physiology, University of Chicago, on "The Effect of Advancing Civilization upon Plants." This paper dealt with the toxic effects of the products of various industries upon plants. Conifers are reported to have been driven from a certain city in England because of the smoke. Conifers are passing away in Chicago. Vegetables die along much travelled tar roads, and also near smelters, due to the presence of sulphur dioxide and sulphur trioxide.

Since plants are so sensitive, we have here a source of real economic loss.

A report was then given of the results obtained in experiments conducted to determine the toxic effect of illuminating gas on the flower of the carnation.

Ethylene was found to be the toxic element in illuminating gas which produces retardation of growth in the bud and withering of the flower. One part of ethylene in 1,500,000 parts of air is sufficient to produce "sleep"—the first step in the withering of the flower.

Results of experiments were then given to show the effects of "laboratory air" upon the growth of etiolated pea seedlings. With the aid of lantern slides these results were compared with those of "check" experiments conducted in pure air. Seedlings grown in "laboratory air" were thicker, shorter, and tended to be diageotropic.

How generally ethylene and other gases are toxic to plants remains to be proven. It is, however, probable that laboratory air has vitiated the results of many experiments in plant and animal physiology.

The discussion which followed Dr. Crocker's paper was of a practical nature.

At 4:30 the session adjourned.

The session was next called to order by the chairman at 10:30 o'clock Saturday morning. The first business was the report of the nominating committee. Miss Faith McAuley submitted the following report of the nominating committee: Chairman, J. G. Coulter, Bloomington, Ill.; Vice-Chairman, Willard N. Clute, Flower Technical High School, Chicago, Ill.; Secretary, Etta M. Bardwell, High School, Cedar Rapids, Iowa.

The report was unanimously accepted.

A most interesting paper was then given by Mr. Lewis H. Weld, Evanston Academy, Evanston, Ill., on "Insect Galls of the Chicago Area." A list of plants and animals which produce galls was given.

The paper dealt largely with a consideration of the Cynipidae. Of the 625 species of Cynipidae in North America about 400 are gall producing. Mr. Weld estimated 1245 known galls in North America.

Methods for collecting and breeding the gall flies were given, as well as the life history of some of the more common species.

A summary was given of the various theories which have been advanced to explain and to account for gall formation. According to the most recent theory, the gall is due to some secretion from the larva.

In the discussion of this paper by F. W. Werner, J. G. Coulter, and W. H. Wright, comment was made upon the interest which might be awakened by working upon just such a problem as that chosen by Mr. Weld.

The round table discussion followed.

A report was given by Mr. Eikenberry, Chairman of the committee appointed to forward co-operative experimentation of the teaching of biology. Other members of the committee had not been appointed and the report showed that no work had been done.

Mr. Eikenberry urged that co-operative work of some kind be done and that scientific methods be applied to biology teaching. He also pointed out the difficulties which arise in the attempts to make such investigations. What problem, or problems should be considered? At present, what method do we have for determining the efficiency of pupils, and hence for testing the results of our experiments? And lastly, if a problem is chosen, will biology teachers carry on such investigations as are necessary for its solution?

On a motion by Mr. Wright the chairman-elect was instructed to appoint a committee to continue the work of the "Scientific Study of Biology Teaching."

Mr. Eikenberry, as editor for the Department of Botany for *SCHOOL SCIENCE AND MATHEMATICS*, urged that more material be sent to him for publication.

The above informal discussion closed the Saturday morning session, and the meeting adjourned.

ADA L. WECKEL, *Secretary*.

MINUTES OF CHEMISTRY SECTION MEETING.

Friday, November 29th.

Chairman J. W. Shepherd presided.

First speaker—F. E. Goodell, Des Moines, Iowa.

For efficient knowledge in chemistry the principles must have thorough treatment. Care should be taken that teachers do not run

afield for industrial experiments and leave the fundamentals out of consideration. Too much is told the student in the manual. There is little material left for student development.

Discussion: Principles are fundamental. All methods are justified by results. If the teacher stimulates his students to use the principles learned and to use them for the benefit of the community, his work needs no other justification. College entrance requirements need not be considered. The kind of teacher is the biggest factor that concerns the value of the work. The kind of text used plays a very small part. The teacher should direct the work, not the text. The practical side is the most effective method of approach by which the student lays hold of principles.

Second speaker—A. C. Norris, Rockford, Ill.

A list of fifty-one practical experiments used in Rockford. An inspiring account of how chemistry serves every day needs of people of this city. The list will be printed in proceedings, and in official journal from time to time.

Committee on Nominations—C. M. Wirick, Chicago; R. D. Barbour, Cadillac, Mich.; Miss Isabel Henkel, Wisconsin.

Committee on Resolutions—R. W. Osborne, Ill.; Miss Loa Green, Mich.; J. M. Schadd, Wis.

Saturday, November 30th.

First speaker—E. F. Downey, Chicago.

Field trips are a source of inspiration to class work. Time can not be found for many. The practical side if carried along with the principles will develop scientific methods of learning by experiment.

Discussion—H. W. Adams, Normal, Ill. The student meets many unsolved questions. They are problems to be solved by laboratory methods. This is a splendid method of approach and emphasizes the value of science studies. Many problems may be found connected with three great problems—combustion, physiological processes and chemical salts. Field trips are made more efficient by careful planning by teacher.

Committee on nominations reported. Officers for next meeting were elected as follows: Chairman, W. F. Roecker, Madison, Wis.; Vice-Chairman, Miss Sarah Nollen, Des Moines, Iowa; Secretary, E. F. Downey, Chicago.

Committee on Resolutions presented the following report which was adopted:

The Committee on Resolutions begs leave to present the following:

Resolved, That a vote of thanks of the Chemistry Section be tendered Prof. Herbert N. McCoy of the University of Chicago for his kindness in presenting to the Section his interesting address on "Recent Advance in Radio-activity," and that a copy of this resolution be mailed him by the Secretary of the Section. Be it also

Resolved, That it be the policy of this Section, through the coming year, to aggressively attack by constructive methods the correlation of chemistry and daily life so that the results of our experiments in this direction may be put into more definite and helpful form and that the assistance of each member of the Section be enlisted toward this end. Be it further,

Resolved, That this section extend to the Northwestern University a vote of thanks for the use of this lecture-room.

Goodell, moved that the Chair appoint a committee of three to per-

fect a list of chemistry experiments concerning daily problems and publish them for members of this section. Motion carried. Committee—H. R. Smith, Chairman, Highland Park, Ill., A. C. Norris, Rockford, Ill.; C. M. Wirick, Crane High School, Chicago.

Adjournment.

HERBERT R. SMITH, *Secretary pro tempore*.

MINUTES OF THE EARTH SCIENCE SECTION.

The twelfth annual meeting of the Earth Science Section of the Central Association of Science and Mathematics Teachers was held in Room 19, University Hall, Northwestern University, Evanston, Ill.

The meeting was called to order at 2 p. m., November 29th, by the Chairman, G. R. Mansfield, of Northwestern University.

The Chairman appointed the following committees:

Nominations—Mr. Peet, Lewis Institute, Chicago; Miss Henderson, State Normal, Whitewater, Wis.; Mr. Clem, Crane Technical High School, Chicago.

Resolutions—Mr. Miller, University High School, Chicago; Miss Smedley, Joliet High School; Miss Mannhardt, Evanston High School.

Prof. W. H. Burge, Northwestern University, then gave an illustrated lecture on "The Earth Measurer, His Life and Work." Following is an abstract of same:

"The U. S. Coast and Geodetic Survey is engaged in making earth measurements of the highest attainable accuracy. Excluding island possessions, the United States has over 10,000 miles of shore line which must be mapped and charted and resurveyed from time to time on account of constant changes. This is done by plane table surveys and by sounding, the location of the soundings being determined by the sextant or some other instrument.

"The plane table is also used for interior surveys, boundary surveys, etc. The method used is called triangulation. A base line is measured forward and backward by tape with an accuracy of one part in a million, so that the two results over a base one mile in length differ only by 6/100 of an inch. The position of one end of the line is found by astronomical means and its true bearing is determined. A third point visible from both ends of the base is selected and the angles of the triangle thus formed are then measured by means of a theodolite placed at each angle of the triangle. By trigonometry the lengths of the other sides are determined and then the latitude and longitude of each corner is computed. The sum of the three measured values of the interior angles of a triangle seldom varies from the true value by more than three seconds of angle and in more than half the cases the difference is less than one second of angle. Lines from the eye to the edges of a foot board forty miles away make an angle of one second. The sides of the first triangle may be used as bases for other triangles and so the survey is expanded in the desired direction, a circuit being planned so as to close on the starting point or on some point, the position of which has been previously determined.

"Obstacles in the line of sight are surmounted by various devices, notably by the construction of rigid observation towers, frequently ninety feet or higher and so constructed as to form really two towers, one within the other. The instrument is placed on the inner tower, while the observer stands on the outer one within the instru-

ment shelter. The course of the proposed survey is traversed in advance by a reconnaissance man or party that selects the points of observation and erects towers. No place is too difficult to penetrate or climb and a high degree of courage and shrewd judgment are required of all men engaged in the work, but particularly of the reconnaissance man.

"For the longer sights an instrument, the heliotrope, consisting of mirrors directed by sights, as in a rifle, is used in connection with powerful bicycle or automobile acetylene lights in night observations. The longest sight ever taken by this method was from Mt. Uncompagne in Colorado to Mt. Ellen in Utah, a distance of 192 miles. The heliotropes and lights are in charge of light keepers, whose movements are directed by flashes in accordance with the telegraphic code.

"The life of the earth measurer, though full of hardship, has many fascinations."

The Committee on Methods of Testing Results of Teaching Physiography gave their final report. Mr. James H. Smith, Austin, Ill., read the results of three tests that had been sent to teachers and given to pupils in twelve schools. This report has already been published in full in *SCHOOL SCIENCE AND MATHEMATICS*, Vol. XII, No. 7, October, 1912, pp. 616-626. The report of the committee was accepted and the committee discharged.

Motion carried that since no formal report could be given by the Committee on Coördination of Science Teaching in High Schools until similar committees had been appointed by the other sections of the Association, the Committee on Coördination of Science Teaching in the High Schools be discharged.

The second session was called to order at 10:30, November 30th.

Dr. J. Paul Goode gave the following lecture: "The Philippines: The Land and the People." (Illustrated.)

The paper was an intensely interesting summary of the geography of the islands, including position, extent, climatic features, vegetation, peoples, pursuits, and economic possibilities. Some of the problems to be faced by the United States government in the development of the islands were indicated. The remarkable progress made by the United States in the Philippines during the past fourteen years was outlined, a record far surpassing that of any other nation that has made any attempt to colonize the tropics. In the opinion of the speaker the islands may not be abandoned by the United States government without a lapse into chaotic conditions and probable annexation by some other power—Germany or Japan.

The Committee on Nominations reported its recommendations: Miss Zonia Baber, University of Chicago, Chairman; Prof. U. S. Grant, Northwestern University, Vice-Chairman; Miss Annie Weller, Charleston, Ill., Secretary. These persons were elected.

The Committee on Fundamentals, W. E. Durstine, Chairman, reported. In the absence of the chairman, the report, an outline for two years' work in the high school, was read by Miss Henderson. The report was accepted and the committee discharged.

The Committee on Resolutions, George J. Miller, Chairman, reported as follows:

Be it

Resolved, That in accordance with the report of the Committee on Methods of Testing Results of Teaching Physiography, that similar tests be given to show the ability of the pupils to apply principles of physiography; and, be it

Resolved, That a committee be appointed to report on a suitable collection of pictures and other illustrative material which will give a pupil more practice in interpreting geographic principles; and, be it

Resolved, That a committee be appointed to submit plans for a four years' course in geography which shall include suitable subject matter in sequence; and, be it

Resolved, That the Earth Science Section use its influence to bring about the conservation of natural areas essential in the teaching of geography and allied sciences; and, be it

Resolved, That the Earth Science Section tender a vote of thanks to Northwestern University for hospitality extended to the association.

GEORGE J. MILLER, LYDIA M. SMEDLEY, MITA MANNHARDT, *Committee.*
BERTHA HENDERSON, *Secretary.*

MINUTES OF THE MATHEMATICS SECTION.

The Mathematics Section of C. A. S. and M. T. held two meetings at Northwestern University, Evanston, Ill., Friday and Saturday, November 29 and 30, 1912.

Friday Afternoon Session.

Since the chairman, Mr. Ira S. Condet, was unable to be present, Mr. Charles W. Newhall, the vice-chairman, presided.

The following nominating committee was appointed: Mr. C. E. Comstock, of Peoria, Ill., Chairman; Miss Jane Pollock, Kenilworth, Ill.; Mr. R. L. Short, Cleveland, Ohio.

Mr. C. E. Comstock gave the report of the Committee on Results, which was continued from 1911. He said that the committee were not sufficiently agreed to make a printed report at this time; but mentioned the following, on which they were agreed:

1. That tests should be made on the amount of algebra which a pupil should be expected to retain at the end of the first year; of geometry at the end of second year; and of algebra at the end of the last year.

2. That the time element is important in mathematical ability.

3. In reading and spelling, powers are always retained; but how much knowledge of algebra does the pupil retain? The committee wants to establish a scale by which one can measure one's own school, a test in algebra, similar to those already made for handwriting and arithmetic.

For special problems, these tests were suggested:

1. Simple expansions.
2. Tests of exponents.
3. Factoring.
4. Simple equations.
5. Addition of fractions.
6. Radicals.
7. Translation.

In the informal discussion which followed, it was suggested by Mr. Hart, of Wisconsin, that these questions be investigated:

1. Can a pupil get something from the book?
2. Can he get something from the class?
3. Can he prove an original?

It was moved by Mr. Collins, seconded by Mr. Jocelyn, and carried, that the report be accepted and the committee continued;

that other members be added; and that the committee report a month before the next meeting.

A comprehensive "Review of the Teaching of Secondary Mathematics for the Past Ten Years," was read by Mr. W. W. Hart, of the University of Wisconsin. It was shown how the interest in mathematics teaching and its improvement in our association is only a part of a world-wide interest.

After mentioning various reports of committees of the Section, he indicated some of their larger tendencies:

1. Simplification of subject matter.
2. Simplification of method.
3. Insistence on thoughtful manipulation.
4. Increased attention to problem material.
5. Unification of mathematics.
6. Improvement in the technique of instruction.
7. The sum total of all the changes means a considerable advance.

Mr. R. L. Short, Principal of West Technical High School, Cleveland, read a paper on "Mathematics and the Vocational School." He showed how the Perry movement marked the time when pure mathematics ceased to rule unchallenged in the secondary school. Economic conditions have forced vocational training into the schools. The question of the day is what kind of mathematics shall be taught in such courses. It cannot be pure mathematics. That has failed. It cannot be shop mathematics. That gives no thought power. And arithmetic alone is not sufficient.

Among the suggestions given were:

1. Teach the law of number, composition of number, and common sense methods of operations.
2. Teach fundamentals of algebra and geometry, and fundamentals only.
3. Add to these, problems which take a form which can be used in the industrial world. You can't teach industrial problems, because neither you nor the child knows any shop language.

On a motion by Mr. Cobb, it was decided that a committee be appointed, with Mr. Short as chairman, to study vocational mathematics.

It was moved by Dr. Slaughter that the committee be seven in number, and the members be selected by the chairman of the committee and the chairman of the Section. The motion was seconded and carried.

Dr. Slaughter spoke of the bill pending in the Illinois legislature, to separate vocational schools and have them under separate boards, which would bring calamitous results.

Mr. Terry suggested that unless there are radical changes made, algebra and geometry can not be kept as prominent as in the past.

The subject of vocational mathematics provoked an interesting discussion.

About 100 were present at the session.

Saturday Morning Session.

The minutes of the 1911 meeting were read and approved; and the treasurer's report was accepted.

The chairman appointed Mr. W. W. Hart, of Madison, Wis., and Miss Jane Pollock, of Kenilworth, Ill., as new members on the Committee on Results.

He also appointed the following committee to investigate vo-

cational mathematics: Mr. R. L. Short, Cleveland, chairman; Mr. George W. Myers, Chicago; Mr. J. V. Collins, Stevens Point, Wis.; Miss Marie Gugle, Toledo, Ohio; Mr. C. I. Palmer, Chicago; Miss Elizabeth McConnell, Indianapolis; Mr. C. A. Petterson, Chicago.

Mr. C. E. Comstock, chairman of the nominating Committee, reported the following names: Mr. Charles W. Newhall, Faribault, Minn., Chairman; Mr. H. L. Terry, Madison, Wis., Vice-Chairman; Miss Marie Gugle, Toledo, Ohio, Secretary

On a motion by Mr. Petterson the Chairman of the committee cast the ballot for the officers nominated.

"The Preparation of Teachers of Mathematics" was discussed by Professor Joseph V. Collins of Stevens Point, Wis. He said that the American Committee of the International Commission had to apologize for American education; that public education has been general and compulsory in the last fifty years; that the mass of teachers are only High School graduates; and that even colleges fill their places from their own graduates.

Although these conditions, and others, as combinations in the country, have improved in the last twenty years, there are still some serious evils:

1. Teachers do not remain long in one place. They go into other occupations, and find it easy to change.
2. The standard seems to be that any graduate of any college is prepared to teach any branch in any high school.
3. The great weakness is the transition from the elementary to the high school. The elementary school teacher is usually a normal graduate, who emphasizes method rather than the academic side. The high school teacher is a college graduate who emphasizes the academic, but has little method.
4. Strong mathematics teachers should be placed in the 8th grades. that untrained teachers can't see why pupils can't see and understand. Teachers should make a study of the dangerous places.

Suggestions:

1. Those who teach in high school should major in their own subject.
2. They should study Educational Psychology and Methods of Instruction; and have observation and practice.
3. Present teachers not so prepared should take work in summer school.
4. Strong mathematics teachers should be placed in the 8th grades.
5. Teachers should attend teachers' meetings and read educational journals.
6. Colleges and Universities should give better preparation for teaching.

Mr. L. P. Jocelyn, of Ann Arbor, gave the report for the Committee on Uniform Notation. As this report was mailed to members, it will be necessary to note only the decisions made by the Section.

$x \doteq \infty$ should be read, x becomes infinite.

Factorial 5 should be written $5!$

The symbol $=^\circ$, equal in degrees, was chosen for the usual one, \sim , is measured by.

$a = \text{inv} \sin x$, was given preference to $a = \sin^{-1} x$.

The symbols of aggregation are considered singular. A quantity is said to be in a parenthesis.

The report is to be revised and printed, and the committee con-

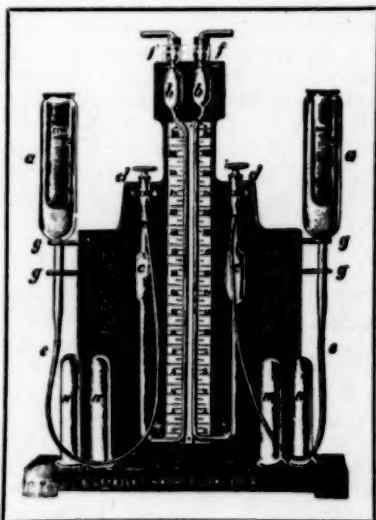
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tinued in power and instructed to secure wide adoption of the uniform notation chosen.

After the discussion of this report the meeting was adjourned.

About thirty-five were present at this session.

E. MARIE GUGLE, *Secretary*.

Toledo, Ohio.

BOOKS RECEIVED.

A Manual of Zoölogy. By Richard Hertwig, University of Munich. Translated by J. S. Kingsley, Tafts College. Pages xii + 606. 15 x 22 cm. Cloth. 1912. Henry Holt & Company, New York.

Elementary Biology Animal and Human. By James E. Peabody, Morris High School, New York, and Arthur E. Hunt, Manual Training High School, New York. Pages xiv + 212. 13 x 19 cm. Cloth. 1912. \$1.00 net. The Macmillan Company, New York.

The A B C of the Differential Calculus. By William D. Wansbrough. Pages xii + 148. 13 x 19 cm. Cloth. 1912. \$1.50 net. D. Van Nostrand Company, New York.

Special Collections in Libraries in the United States. By W. Dawson Johnston and Isadore G. Mudge, Columbia University. 140 pages. 15 x 23 cm. Paper. 1912. Government Printing Office, Washington.

Teachers' College Bulletin, Columbia University, New York. 35 pages. 15 x 22 cm. Paper. 1912.

Bibliography of Child Study for 1910-1911. Compiled by Clark University Library, Worcester, Mass. 90 pages. 15 x 23 cm. 1910. Books and articles. Paper. 1912. Government Printing Office, Washington.

Commercial Values. An Atlas of Raw Materials of Commerce and Commercial Interchanges. By Mack Jefferson, Michigan State Normal School. 64 pages. 17 x 26 cm. Paper. 1912. Ginn & Company, Boston.

Principles of Economic Zoölogy. By L. S. Dougherty, Normal School, Kirksville, Mo., and M. C. Dougherty, Kirksville, Mo. Pages vii + 410. 301 Illustrations. 14 x 21 cm. Cloth. 1912. \$2.00 net.

Field and Laboratory Guide, Part I. Principles of Economic Zoölogy. By same authors as above. Pages vi + 276. 14 x 21 cm. Cloth. 1912. \$1.25 net. W. B. Saunders Company, Philadelphia.

Experimental and Theoretical Course of Geometry. By A. T. Warren, William Ellis Endowed School, N. W. Pages viii + 298. 13 x 19 cm. Cloth.

Junior Mathematics. By David B. Mair. Pages viii + 208. 13 x 19 cm. Cloth.

Elementary Trigonometry. By W. E. Paterson, Mercers' School. 248 pages. 13 x 19 cm. Cloth. 1911. The Carendon Press, Oxford.

Annuario Biographico del Circolo Matematico di Palermo. 1912. Paper. 192 pages.



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This botany meets the great and increasing demand for a textbook which shall present the subject in a scientific manner and, at the same time, emphasize the relations of plants to everyday life.

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A Second Course in Algebra

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BOOK REVIEWS.

Alternating Currents Simplified, by Elmer E. Burns, *Medill High School, Chicago*. Pages iv + 199. 13 x 19 cm. Cloth. 1912.

Joseph G. Branch Publishing Company, Chicago.

This is a book worth while owning. It is written by one who is eminently qualified both from an academic and practical point of view to produce a book at once helpful to pupil, practical electrical worker and instructor. The object of the book is to give the reader, whoever he may be, a clear understanding of the production and action of alternating currents. It is not cumbered with descriptions of electrical machinery but strikes immediately at the fundamentals of alternating currents, explaining the underlying principles in a way that cannot be misunderstood.

Too much cannot be said in praise of the book. Its statements are clear and accurate. There are fourteen chapters and eighty-eight figures and illustrations. There are splendid indices to topics and illustrations. Mechanically the book is well made, the type clear and of a character to make the book one easy to read. It is a book which should be in the hands of every one interested in electricity. C. H. S.

Practical Mathematics, by Claude I. Palmer, *Assistant Professor of Mathematics, Armour Institute of Technology*. 1912. McGraw-Hill Book Company, New York. Part I, Arithmetic. Pages, x + 139. 12 x 18 cm. Price, 75 cents. Part II, Geometry. Pages, xii + 152. 12 x 18 cm. Price, 75 cents.

These two volumes are the direct outgrowth of a course in practical mathematics given in the evening classes of the Armour Institute, and are written for men who have come to realize the need of getting hold of mathematics if they are to make any advance in their work.

Part I deals with arithmetic and its applications. The topics included are: common fractions, decimal fractions, short methods and checks, weights and measures, percentage, ratio and proportion, density and specific gravity, and powers and roots. The subjects are presented in a simple way in order that the man who has forgotten the arithmetic he learned in school may grasp them readily. The large number of problems and exercises give ample drill in learning to attack problems and in gaining facility in performing the arithmetical operations. Most of the problems are new, while many are adapted from engineering journals, handbooks, and so on; they are close enough to the real problems that men meet in their daily work to appeal to the interest and seem worth while working.

Part II, Geometry with Applications, aims to present the principles and facts of the subject so that they will seem reasonable, and to state definitions so as to give a clear idea of the things defined without attempting to make them rigorously exact. The topics considered are: plane surfaces, lines, and angles; triangles; circles; graphical methods; prisms; cylinders; pyramids, cones, and frustums; the sphere; anchor ring; and prisms. The student gains a knowledge of the principles of geometry by applying them in problems that arise in shops and in the trades.

This series is well printed in large clear type, with plenty of diagrams and illustrations, and in choice of subject-matter and method of presentation seems well suited to the needs of classes in evening, trade, and continuation schools.

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Toys and Toymaking, by George L. Johnson, Inspector of Handwork, Liverpool Education Committee. 160 pages. 14 x 22 cm. Cloth. 1912. Longmans, Green & Co., New York.

A book written for the child by one who knows how to amuse and at the same time instruct him. Of the many impulses possessed by children none are more pronounced than those for *play* and *construction*. It is for utilizing these characteristics to the very best advantage that this book was written. As one of the means for educating the child in the home this book will be found most helpful.

The exercises given are those which are, very largely, based on the interests of the child when he desires to be doing something. The materials employed are of simplest kind and inexpensive. Children who are able to read will amuse themselves alone, or with their playmates, in constructing the toys described. The book is a splendid help in the kindergarten.

The left hand pages are given to the description of how to construct the particular toy, while the right hand pages contain the workings, drawings and pictures of the completed toy. Mothers and teachers of children will find this a most helpful book. It is one which ought to be in every well regulated home where there are young children.

C. H. S.

Shop Mathematics, Part I, Shop Arithmetic, by Earle B. Norris and Kenneth G. Smith, Associate Professors of Mechanical Engineering, University of Wisconsin. Pages, xi + 187. 16x24 cm. 1912. Price, \$1.50. McGraw-Hill Book Company, New York.

To teach men and boys employed in shops to solve problems that arise in their daily work is quite different from teaching school boys the applications of mathematics. In the former case the problems already exist and are highly specialized, while the men and boys who must solve them, for the most part, have had little training in mathematical thinking and manipulation; in the latter case the "shop" or "applied" problems are brought in for the purpose of illustrating and applying principles and the pupils are being trained, with more or less success, to attack problems that may arise in various fields of future endeavor.

The present volume is the result of several years experience in teaching shop men to use the fundamental principles of mathematics in solving problems. For the most part the problems are those of the metal working trades. The first twelve chapters deal with various topics of elementary arithmetic. Common and decimal fractions, percentage, ratio and proportion, areas and volumes, and powers and roots are discussed in an elementary way to meet the needs of those who have had little or no training in arithmetic. The explanations and illustrative problems seem to be very clear and easy of comprehension, and the problems given are not too difficult for beginners.

The last eight chapters deal with levers, tackle blocks, the inclined plane and screw, work and power, horse-power of engines, mechanics of fluids, heat, and strength of materials. The problems are intended to give further practice in calculation and the handling of simple formulas and to lead to an understanding of the principles of machines. While teachers in trade and industrial schools will be especially interested in this book it should be examined by all teachers of high school mathematics. If it can not be used as a text-book it will prove a valuable reference book.

H. E. C.